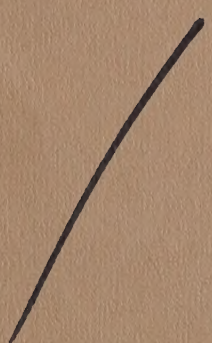
KEITHLEY

Operators Manual
Model 192 Programmable DMM

Contains Operating Instructions for Models 192, 1910, and 1923

(Rev. C)



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Keithley Instruments, Inc.
28775 Aurora Road/Cleveland, Ohio 44139/(216) 248-0400

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Operators Manual
Model 192
Programmable DMM

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SECTION 1. GENERAL INFORMATION

1-1. INTRODUCTION

1-2. The Keithley Model 192 is a 6½ digit, 2,000,000 count, fast autoranging DMM. With the IEEE 488 Interface option (Model 1923) the 192 becomes fully programmable. DC volts and ohms functions are standard. Measurements of 1mV to 1200V are attainable on 5 voltage ranges, and 2- and 4-terminal measurements of 1mΩ to 20MΩ are attainable on 6 resistances ranges. With the addition of the Model 1910 AC Voltage Option, the 192 will provide readings from 1μV to 1000VAC on four ranges. Because the Model 1923 and 1910 are easily field installed, these available options can be added at any time.

1-3. Other features of the 192 include:

- **Front Panel Programs** - The internal programs in the 192 are accessible from the front panel. Descriptions of these programs can be found on the Specification Sheet and in Section 5 of this manual.
- **Data Storage** - Registers for storing 100 readings are provided in the basic 192. These storage registers are utilized by Front Panel Program 7, Data Logger (see Section 5).
- **Multiple Inputs** - Multiple inputs provide access to DCV, ACV, and Ohms terminals simultaneously. This enables systems designers to optimize their switching matricies for the parameter being measured. In addition, in some simple systems, switching can be eliminated altogether. For systems that require only one input, the Model 1924 Rear Panel Input Adapter is available as an option.
- **One Button Zero** - The front panel zero is activated by pushing one button, as compared to competitive units which require up to 6 steps. The zero offset is automatically scaled when range is changed, and different offsets are saved for each function.

1-4. OPTIONAL ACCESSORIES

1-5. This section describes the various accessories and options available for use with the Model 192 DMM.

1-6. Model 1019 Universal Rack Mounting Kit

1-7. The Model 1019 is a Universal Rack Mounting Kit for the Model 192. Two different front panels are provided to allow left, right, or dual, side by side installation. Installation procedures can be found in Section 2.

1-8. Model 1600 High Voltage Probe

1-9. The Model 1600 extends the DMM to 40kV. It has a 1000:1 division ratio which means that 1 volt on the DMM corresponds to 1kV.

To Operate: Set the DMM to DCV and 200 Volt range. Connect the alligator clip on the Model 1600 to source low. Connect the probe tip to source high.

Specifications: Voltage Range: 0 to 40,000 volts DC.
Input Resistance: 1000 megohms.
Division Ratio: 1000:1
Ratio Accuracy:
±1.5% at 25kV, decreasing to ±2.0% at 20kV and 30kV
±3.0% at 10kV and 40kV, and ±4.0% at 1kV.
Ratio Stability: ±0.01% per °C; ±0.1% per year.
Heating Effects: Self-heating due to application of high voltage for period in excess of 1 minute will cause a maximum of 0.2% additional error at 40kV (error is less at lower voltage).

1-10. Model 1641 Kelvin Test Lead Set

1-11. The Model 1641 test leads are for use in making 4-terminal measurements. The test leads (1 pair) are 1.2m (48 inches) long twin-lead cables. Each cable is terminated by a twin-banana plug and a spring-clip Kelvin contact. Plug twin banana plug into DMM horizontally (HI to HI and LO to LO).

1-12. Model 1651 50 Ampere Shunt

1-13. The Model 1651 allows current measurements to be made from 0 to 50 amperes DC and from 10 to 50 amperes AC with AC Voltage option. It is a 0.001 ohm ±1% 4-terminal shunt. A fifty ampere current will correspond to 50 millivolts.

To Operate: Connect separate current leads (not furnished) between the source and the Model 1651 hex-head bolts. Use leads that are rated up to 50 ampere capacity. Connect the voltage leads (furnished) between the Model 1651 screw terminals and the DMM INPUT terminals. Set the DMM to ACV and 2V range or DCV and 200 millivolt range. Use NULL to zero on DC 200mV.

1-14. Model 1681 Clip-On Test Lead Set

1-15. The Model 1681 contains two leads 1.2m (48 inches) long, terminated with banana plug and spring-action clip-on probe.

1-16. Model 1682 RF Probe

1-17. The Model 1682 extends the AC voltage response of the Model 192 from 100kHz to 100MHz.

To Operate: Set the DMM to DCV and 200 volt range. Connect the Model 1682 to the DMM INPUT terminals.

Specifications: Voltage Range: 0.25 to 30 volts rms.
Transfer Accuracy: ±0.5dB, 100kHz to 100MHz peak responding calibrated in rms of sine wave.
Input Impedance: 4 megohm shunted by 3pF.
Maximum Allowable Input: 30V rms AC, 200V DC.
Accessories Supplied: Straight tip, hook tip, ground clip, hi adapter, banana plug adapter.

1-18. Model 1683 Universal Test Lead Kit

1-19. Two test leads, 1.2m (48 inches) long with 12 screw-in tips, 2 banana plugs, 2 spade lugs, 2 alligator clips with boots, 2 needle tips with chucks and 4 heavy duty tip plugs.

1-20. Model 1685 Clamp-On AC Current Probe

1-21. The Model 1685 measures AC current by clamping onto a single conductor. Interruption of the current path is unnecessary. The Model 1685 detects current by sensing magnetic field produced by current.

To Operate: Set the DMM to ACV and 20 volt range. Connect the Model 1685 to the DMM.

1-22. Model 1901 Current Adapter

1-23. The Model 1901 allows your DMM to read DC current from 1nA/digit to 2000mA. With the 1910 AC Voltage Option it reads from 10nA/digit to 2000mA. The Model 1901 plugs into the INPUT terminals of the 192. Maximum allowable con-

tinuous voltage drop (full scale input voltage burden) is 200mV. Shunt resistors are connected so as to eliminate contact resistance errors. Use the Model 192 200mV DC range and 2V AC range, for DC current and AC current respectively. Input voltage burden can be reduced by selecting the lowest shunt that provides the necessary resolution.

1-24. Model 1910 AC Voltage Option

1-25. The Model 1910 is a factory or field installable option which allows your DMM to read AC volts from 10μV/digit to 1000V. The Model 1910 is internally installed in the Model 192. It is important to note that field installation or removal/-replacement of the 1910 requires recalibration of AC voltage. Specifications for the 1910 are listed at the end of this section and AC voltage measurements are described in Section 4, Paragraph 4-21.

1-26. Model 1923 IEEE-488 Interface

1-27. The Model 1923 is a microprocessor-based IEEE Standard 488-1977 interface that provides the logic and controls necessary to interface the 192. In the Talk Only mode the 192 can send data to one or more listeners without the use of a controller. In the Talk/Listen mode the 192 can send or receive data over the IEEE Bus when addressed by a systems controller.

1-28. Model 1924 Rear Input Adapter

1-29. The basic 192 has multiple inputs on the front panel. The Model 1924 Rear Input Adapter used with the Model 1923 IEEE Option allows multiple and single rear input.

1-30. WARRANTY INFORMATION

1-31. The Warranty is given on the inside front cover of this Instruction Manual. If there is a need to exercise the Warranty, contact the Keithley Representative in your area to determine the proper action to be taken. Keithley maintains service facilities in the United Kingdom and West Germany, as well as in the United States. Check the inside front cover of this manual for addresses.

1-32. CHANGE NOTICES

1-33. Improvements or changes to the instrument which occur after printing of the Instruction Manual will be explained on a Change Notice sheet attached to the inside back cover.

1-34. SAFETY SYMBOLS AND TERMS

1-35. Safety symbols used in this manual are as follows:

The symbol on the instrument denotes that the user should refer to the operating instructions.

The symbol on the instrument denotes that 1000V or more may be present on the terminal(s).

The **WARNING** used in this manual explains dangers that could result in personal injury or death.

The **CAUTION** used in this manual explains hazards that could damage the instrument.

1-36. UNPACKING AND INSPECTION

1-37. The Model 192 was carefully inspected both mechanically and electrically before shipment. Upon receiving the Model 192, unpack all items from the shipping container and check for any obvious damage that may have occurred during transit. Report any damage to the shipping agent. Retain and use the original packaging materials if reshipment is necessary. The following items are shipped with all Model 192 orders:

A. Model 192 Programmable DMM

B. A copy of the Operator's Manual and Service Manual.

NOTE

If the Service Manual is not included with this shipment, return the Service Manual Request Card located in the back of this manual. The Service Manual will be sent as soon as it is available.

C. Installed or separate optional accessories, as ordered.

1-38. PREPARATION FOR USE

1-39. The Model 192 is shipped ready for use on the line voltage marked on its rear panel. The line frequency (50 to 400Hz is selected automatically by the 192 during power up. If the Model 1923 IEEE interface is installed, it will be set to the Addressable mode and at Address 8.

1-40. LINE POWER

1-41. The Model 192 is provided with a 3-wire line cord which mates with a third wire earth grounded receptacle. The instrument will operate on two voltage ranges, of 50 to 400Hz AC power. The two ranges are listed in Table 1-1.

Either of these ranges may be selected by positioning an internal slide switch and installing the appropriate fuse for that range. An optional line voltage range of 90 to 110 volts, and 180 to 220 volts is available by special order. Instruments with this range use a different transformer.

CAUTION

To avoid instrument damage, the line voltage switch must be in the correct position and the correct fuse installed (for the line voltage being used) before the instrument is turned on.

NOTE

The line voltage setting of the instrument is marked on the rear panel. The following procedure can be used to either confirm the factory setting, or to set up the instrument for operation on another voltage range. If the line voltage range is changed, the box next to the selected line voltage should be appropriately marked as an external reminder of the setting. Use a water soluable marking pen.

1-42. Line Voltage Selection

1-43. Set up the Model 192 to operate on the available AC line voltage as follows:

A. Remove the top cover per instructions in Section 2, Paragraph 2-3.

B Using Table 1-1, set the switch S102 (see Figure 2-1) accordingly.

C Install the proper rated line fuse as explained in Section 2, Paragraph 2-4.

1-44. Line Frequency Selection

1-45. Line frequency is selected automatically by the 192 during power up. The instrument will operate at 50 to 400Hz and will display that frequency momentarily on power up.

1-46. IEEE Switching Programming

1-47. The switches for programming the IEEE Interface are located at the rear panel of the 192. The interface can be set to the Talk Only mode or the Addressable mode. Programming instructions can be found in Section 6, Paragraph 6-3.

1-48. SPECIFICATIONS

1-49. Detailed specifications for the Model 192 are given on the following pages.

TABLE 1-1
LINE VOLTAGE SELECTION

INPUT VOLTAGE	SWITCH S102
90-110V*	115V
105-125V	115V
180-220V*	230V
210-250V	230V

* Requires special factory installed transformer.

Model 192 Programmable DMM Specifications

DC VOLTS

RANGE	RESOLUTION 6½*	5½	4½**	INPUT RESISTANCE	5½-DIGIT ACCURACY ±(% of rdg + digits) 24 HR. 23°C ±1°C	90 DAYS 18° to 28°C	1 YEAR 18° to 28°C	TEMPERATURE COEFFICIENT ±(% rdg + digits)/°C 0°-18°C & 28°-50°C
0.2 V		1 μV	10 μV	> 1000MΩ	0.004+2***	0.005+2***	0.009+2***	0.0003+1
2 V	1 μV	10 μV	100 μV	> 1000MΩ	0.003+1.5	0.005+1.5	0.007+1.5	0.0003+0.1
20 V	10 μV	100 μV	1mV	> 1000MΩ	0.003+1	0.005+1	0.009+1	0.0004+0.1
200 V	100 μV	1mV	10mV	10MΩ	0.004+2	0.007+2	0.010+2	0.0007+0.1
1200 V	1mV	10mV	100mV	10MΩ	0.004+1	0.007+1	0.011+1	0.0007+0.1

*Multiply digit error by 10 for 6½-digit accuracy.
**Using Model 1923 Interface.
***After pushbutton zeroing.

MAXIMUM ALLOWABLE INPUT: 1200V peak.

CMRR: Greater than 120dB at DC and 50 or 60Hz (with 1kΩ in either lead).

NMRR: Greater than 60dB at 50 or 60Hz.

BENCH READING RATE: 8/s.

SETTLING TIME: 250ms to within 6 digits at 5½-digit resolution.

RESISTANCE

RANGE	RESOLUTION 6½*	5½	4½**	MAXIMUM OUTPUT I SHORT	V OPEN	5½-DIGIT ACCURACY ±(% of rdg + digits) 24 HR. 23°C ±1°C	90 DAYS 18°-28°C	1 YR. 18°-28°C	TEMP. COEFFICIENT ±(% rdg+digits)/°C 0°-18°C & 28°-50°C
0.2 kΩ		1mΩ	10mΩ	−5 mA	−0.5V	0.0035+2***	0.007+2***	0.010+2***	0.001 +0.7
2 kΩ	1mΩ	10mΩ	100mΩ	−5 mA	−5 V	0.0035+2	0.007+2	0.010+2	0.001 +0.1
20 kΩ	10mΩ	100mΩ	1 Ω	−500 μA	−5 V	0.0035+1	0.007+2	0.010+2	0.001 +0.1
200 kΩ	100mΩ	1 Ω	10 Ω	−50 μA	−5 V	0.0035+1	0.007+2	0.010+2	0.001 +0.1
2000 kΩ	1 Ω	10 Ω	100 Ω	−5 μA	−5 V	0.005 +1	0.010+2	0.010+2	0.0012+0.1
20 MΩ	10 Ω	100 Ω	1 kΩ	−0.5 μA	−5 V	0.020 +1	0.040+1	0.040+1	0.005 +0.1

*Multiply digit error by 10 for 6½-digit accuracy.
**Using Model 1923 Interface.
***After pushbutton zeroing.

CONFIGURATION: Automatic 2- or 4-terminal.

MAXIMUM ALLOWABLE INPUT: 360V peak or 250V rms.

BENCH READING RATE: 8/s on 0.2kΩ—2000kΩ ranges; 4/s on 20MΩ range.

SETTLING TIME: 250ms to within 6 digits at 5½-digit resolution on 0.2kΩ--2000kΩ ranges; 500ms on 20MΩ range.

AC VOLTS (Option 1910)

RANGE	RESOLUTION 6½*	5½	4½**	5½-DIGIT ACCURACY ±(% of rdg + digits) 1 YEAR, 18°-28°C (above 1000 counts) 50Hz-20kHz	20Hz-50Hz and 20kHz-100kHz	TEMPERATURE COEFFICIENT ±(% rdg + digits)/°C 0°-18°C & 28°-50°C 50Hz-20kHz	20-50Hz & 20kHz-100kHz
2 V	1 μV	10 μV	100 μV	0.1 +10	1+20	0.015+0.5	0.05+0.5
20 V	10 μV	100 μV	1mV	0.1 +10	1+20	0.015+0.5	0.05+0.5
200 V	100 μV	1mV	10mV	0.1 +10	1+20	0.015+0.5	0.05+0.5
1000 V	1mV	10mV	100mV	0.15+10†	1+20‡	0.020+0.5†	0.05+0.5‡

*Multiply digit error by 10 for 6½-digit accuracy.
**Using Model 1923 Interface.
†50Hz-10kHz.
‡20Hz-50Hz & 10kHz-20kHz.

RESPONSE: Average, calibrated in rms of a sine wave.

MAXIMUM ALLOWABLE INPUT: 1000V rms sine or DC, 2×10^7 V•Hz.

CMRR: Greater than 60dB at DC, 50 & 60Hz (1kΩ in either lead).

INPUT IMPEDANCE: 2MΩ shunted by less than 50pF.

BENCH READING RATE: 2/s.

SETTLING TIME: Less than 1.3s to within 0.05% of final reading.

GENERAL

RANGING: Manual or Fast Autoranging (less than 150ms per range change on DCV).

ZERO: Pushbutton zeroing of offsets.

DISPLAY: Seven 0.5-inch LED digits with appropriate decimal point.

OVERRANGE INDICATION: Display indicates polarity and OFLO.

ISOLATION: Input LO to IEEE LO or power line ground: 1400V peak, 5×10^5 V•Hz; greater than 10⁹Ω parallel by 100pF.

WARMUP: 1 hour to rated accuracy.

ENVIRONMENTAL LIMITS: Operating: 0°-50°C, 0% to 80% relative humidity up to 35°C. **Storage:** −25°C to 65°C.

POWER: 105-125 or 210-250 volts (internal switch selected), 50Hz-400Hz, 30V•A maximum.

INPUT CONNECTORS: 5-way binding posts.

DIMENSIONS, WEIGHT: 127mm high × 216mm wide × 359mm deep (5" × 8½" × 14⅛"). Net weight 3.4kg (7.5 lbs.).

ACCESSORIES AVAILABLE:

Model 1019 Universal Rack Mounting Kit
Model 1600 High Voltage Probe
Model 1641 Kelvin Test Lead Set
Model 1651 50-Ampere Shunt
Model 1681 Clip-On Test Lead Set
Model 1682 RF Probe
Model 1683 Universal Test Lead Set
Model 1685 Clamp-On Current Probe
Model 1901 Current Adapter
Model 1910 ACV Option
Model 1923 IEEE-488 Interface
Model 1924 Rear Input Adapter

Prices and specifications subject to change without notice.

For more information on specifications, refer to the Model 192 Operator's Manual, P/N 30839.

MODEL 1923 IEEE-488 INTERFACE SPECIFICATIONS

I. IEEE-488-1978 BUS IMPLEMENTATION:

Multiline Commands: DCL, SDC, GET, LLO, GTL, UNT, UNL, SPE, SPD.

Uniline Commands: IFC, REN, EOI, SRQ, ATN.

Programmable Parameters: Function, Range, Zero, Trigger Modes, Delay, EOI State, SRQ Bus Response, Data Terminators, Data Store to 100 Readings.

Conversion Rates: Nine different conversion rates may be selected; fastest modes for DC volts are:

USEABLE RESOLUTION	INTEGRATION PERIOD	TRIGGER TO FIRST BYTE OUT
4½-digits	4.4ms	27ms
5½-digits	16.67ms*	39ms

*20ms at 50Hz.

Data String: 16 bytes (excluding terminators).

4½-digit accuracy: ±(.015% + 1d) for 1 year on DCV and Ohms (below 2000kΩ).

Address Modes: TALK ONLY and ADDRESSABLE.

II. STATUS PORT:

Separate port providing function and HI LO PASS outputs (open collector, 100mA sink).

FRONT PANEL PROGRAMS

PROGRAM	NAME	DESCRIPTION
0	CLEAR	Cancels Programs 3 through 7.
1	RESOLUTION	Selects 5½- or 6½-digit resolution.
2	FILTER	Selects extra digital filtering.
3	OFFSET/SCALE	Displays the result of Y=sX+b. s and b are entered from the front panel.
4	% DEVIATION	Displays the percent deviation from an entered value.
5	MIN/MAX	Remembers the minimum and maximum reading for front panel recall.
6	HI/LO/PASS	Displays HI, LO or PASS defined by entered limits. Status output available with 1923 option.
7	DATA LOGGER	Saves up to 100 readings for front panel recall. Interval programmable up to 1 hour.

192 SPECIFICATION CLARIFICATIONS

The following information is supplied as clarification of the 192 specifications.

1. NMRR - To prevent AD saturation, peak AC + DC value must be less than full scale on any range.

2. IEEE low to power line ground isolation is 1MΩ in parallel with .02μF.

3. Four terminal lead resistance: Maximum per lead for additional 1-digit error at 5½ digits.

RANGE	RESISTANCE
.2k	7Ω
2k	22Ω
20k	70Ω
200k	220Ω
2000k	700Ω
20M	2200Ω

4. Input current. With 1MΩ shunt on 2V range, display should be less than 5 digits (<50pA) at T_A = 23°C (use filter Program 2).

SECTION 2. MAINTENANCE AND INSTALLATION PROCEDURES

2-1. GENERAL

2-2. This section contains information necessary for removal/installation of the 192 top cover and replacement of the line power fuse. Also included are instructions for the installation of available optional accessories.

WARNING

To avoid dangerous electrical shock:

1. The installation and maintenance procedures in this section should only be performed by qualified personnel.
2. Set the power switch to the off (out) position and disconnect the AC line cord and all test leads from the instrument.

2-3. Top Cover Removal/Installation

A. Remove the two retaining screws located at the rear of the instrument.

B. Grasping the top cover at the rear, carefully lift it off the instrument.

C. When installing the top cover, reverse the above procedure, making sure that the three tabs located at the front of the cover engage into the front panel assembly.

2-4. Line Power Fuse (F101) Replacement

2-5. The fuse is accessible from the 192 rear panel. To replace, proceed as follows:

A. Turn power off by depressing the Model 192 power button and disconnect the line cord.

B. The fuse carrier is spring loaded. Using a slotted screwdriver, push the fuse carrier in and rotate ¼ turn counterclockwise. The carrier and fuse will eject from the holder.

C. Remove the fuse from the carrier and replace per Table 2-1.

D. To install the fuse and carrier into the holder, reverse the procedure in Step B

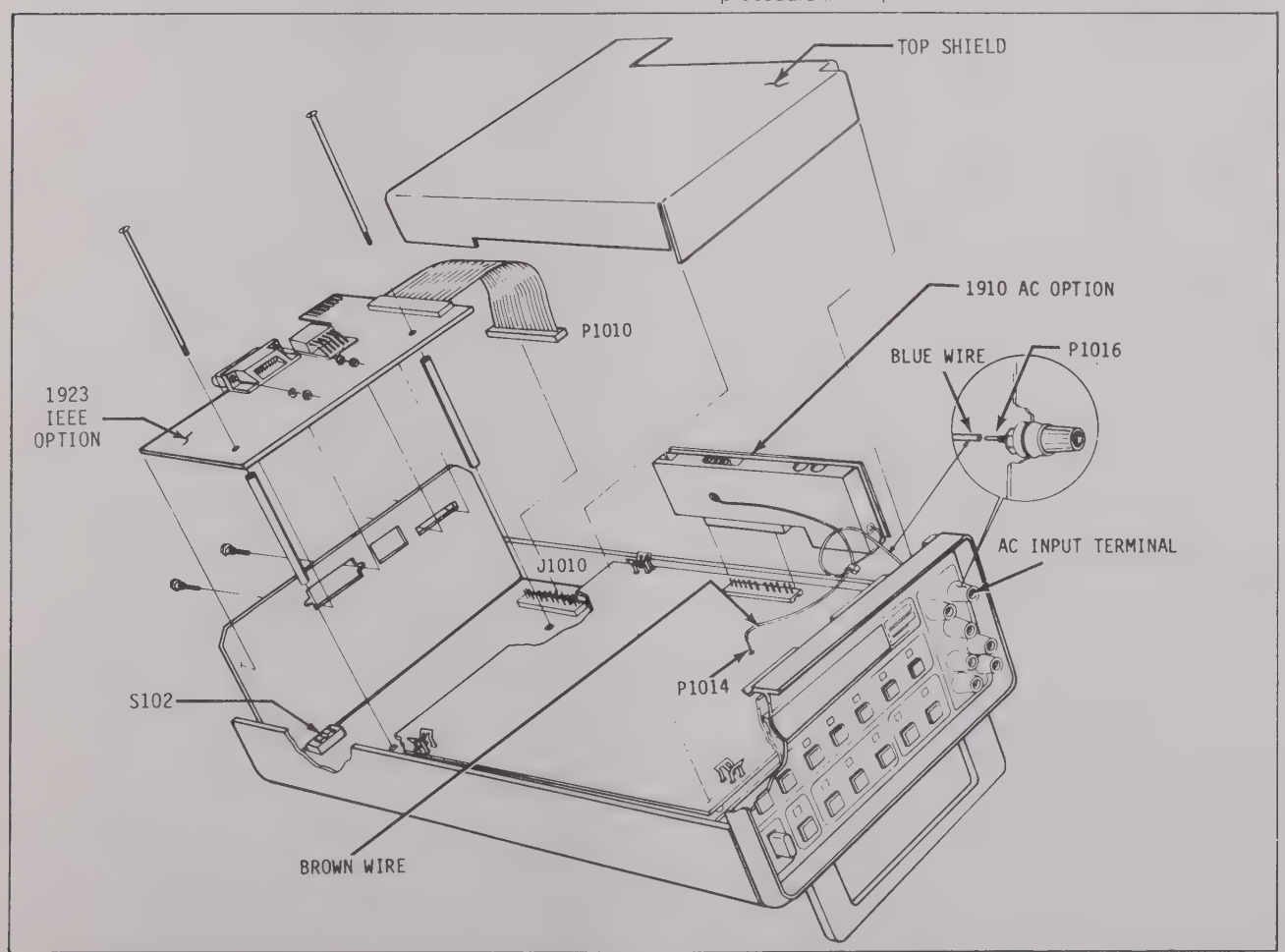


FIGURE 2-1. ACCESSORY INSTALLATION

TABLE 2-1
FUSE REPLACEMENT

Line Voltage	Fuse F101	Keithley Part No.
105-125V	¼A, 250V, 3AG, SLO BLO	FU-17
195-235V	⅛A, 250V, 3AG, SLO BLO	FU-20

2-6. Model 1910 AC Voltage Option Installation (Optional Accessory)

2-7. If the AC Voltage option was not factory installed, it can be easily field installed by performing the following procedures. Refer to Figure 2-1.

A. Remove the 192 top cover per instructions in Paragraph 2-3.

B. Remove the top shield from the analog board by gently lifting it off the four retaining clips.

C. Plug the 1910 into its mating receptacle on the analog board.

D. Connect the brown wire of the ACV option to P1014 on the analog board. Connect the blue wire to P1016, which is located on the ACV input terminal.

E. Replace the top shield of the analog board. Take care not to pinch any wires when engaging the shield into the retaining clips.

F. After installing the 1910, it will be necessary to perform the AC Volts portion of the calibration procedure. The calibration procedure can be found in the Service Manual. If the Service manual was not supplied with the 192, an addendum can be found in the back of this manual which contains the calibration procedure.

G. Replace the top cover per the instructions in Paragraph 2-3.

2-8. Model 1923 IEEE Interface Installation (Optional Accessory)

2-9. If the IEEE Interface was not factory installed, it can be easily field installed by performing the following procedures. Refer to Figure 2-1.

A. Remove the 192 top cover per instructions in Paragraph 2-3.

B. Remove the plate on the 192 rear panel that covers the IEEE access holes. Two Phillips screws secure the plate to the rear panel.

C. The panel mount hardware kit may be attached to the IEEE connector as shown in Figure 2-2. If so, remove the hardware from the connector before proceeding.

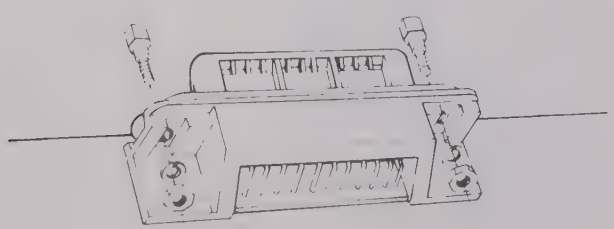


FIGURE 2-2. IEEE CONNECTOR

D. Plug the ribbon cable connector (P1010) into the 34-pin connector (J1010) on the mother board.

E. Insert the two 3-inch long #4-40 screws through the IEEE board and through the nylon spacers. Position the IEEE board so that the IEEE and Status Output connectors protrude through the 192 rear panel.

F. Loosely secure the IEEE board to the mother board with the 3-inch long screws.

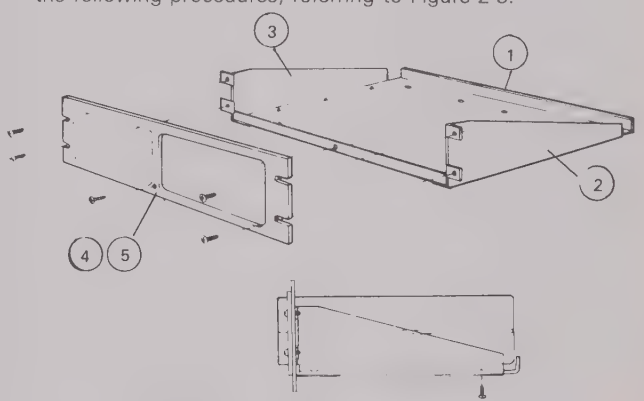
G. Loosely secure the IEEE connector to the 192 rear panel using the panel mount hardware kit.

H. Tighten the 3-inch long screws first, and then tighten the screws securing the IEEE connector to the rear panel.

I. Replace the top cover per instructions in Paragraph 2-3.

2-10. Model 1019 Rack Mounting Kit (Optional Accessory)

2-11. The Model 1019 is a universal rack mounting kit for the Model 192. Two different front panels are provided to allow left, right or dual (side-by-side) installation. To install, perform the following procedures, referring to Figure 2-3.



PARTS LIST

ITEM	DESCRIPTION	QTY.
1	Support Plate	1
2	Right Hand Bracket	1
3	Left Hand Bracket	1
4	Dual Front Panel	1
5	Single Front Panel	1

FIGURE 2-3. RACK MOUNT INSTALLATION

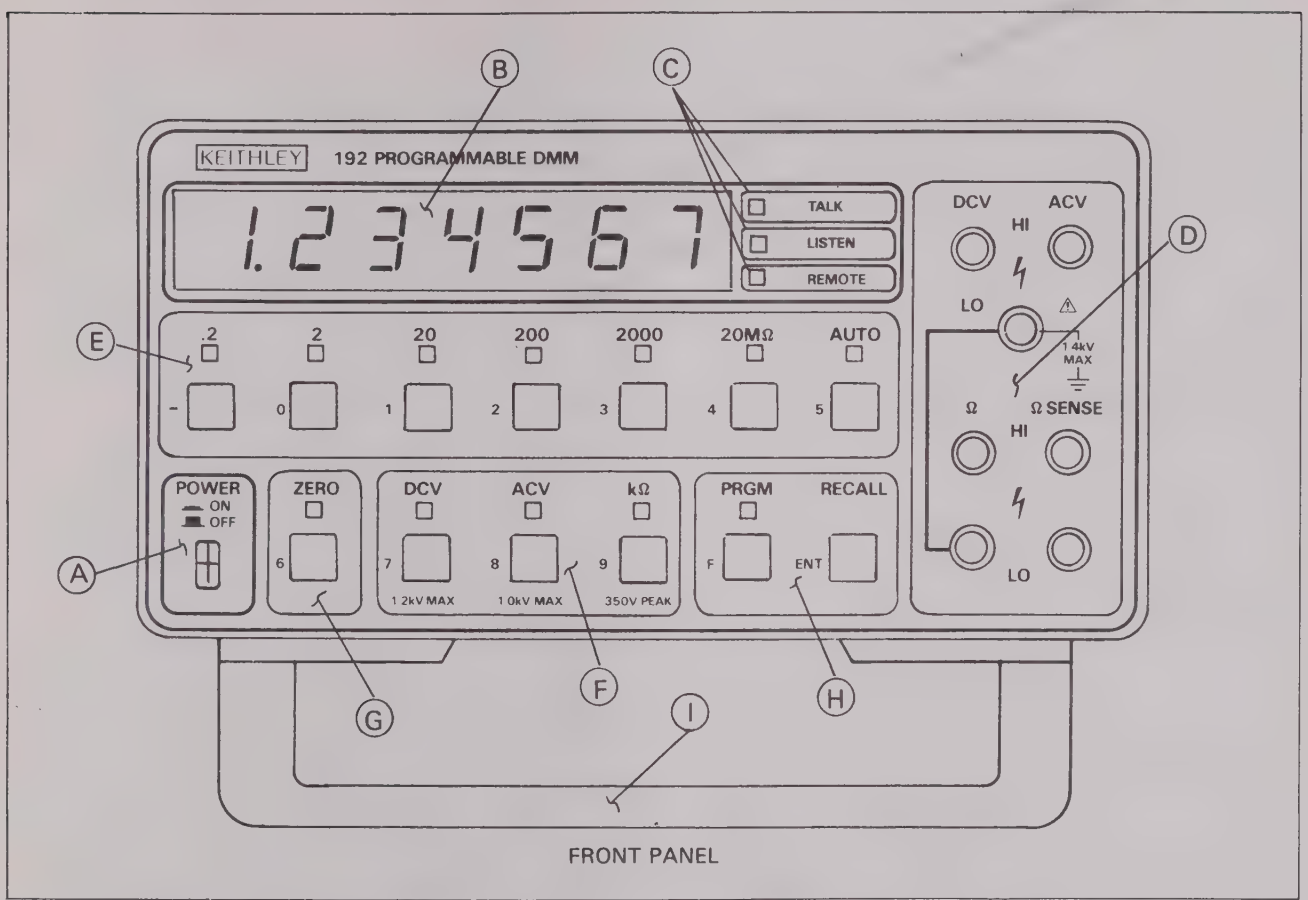
A. Assemble right and left hand brackets (Items 2 and 3) to support plate (Item 1) using six #8-32 Kep nuts (Item 6).

B. Install support plate assembly (Step 1) and either dual or single front panel (Item 4 or 5) to rack mounting flange as shown. (Mount panel from outside rack and support plate from inside rack.) Fasten securely with four #10-32 × ½ in. truss head screws.

C. Install center support screw through front panel and fasten support plate.

D. Remove rubber feet (four) from instrument case and place instrument on support plate from rear of rack. Push instrument forward through hole in front panel until holes in rear feet of instrument case are aligned with mating holes in plate. Secure instrument to plate with two #6-32 × ½ self threading screws , being careful not to over-torque screws.

SECTION 3. FRONT AND REAR PANEL FAMILIARIZATION



FRONT PANEL

3-1. FRONT PANEL

3-2. The following information describes the features of the 192 front panel.

(A.) **Power ON/OFF Switch** - Power is ON with switch IN; power is OFF with switch OUT.

(B.) **Display** - As a bench DMM, 5½ digits of resolution is standard. The utilization of Front Panel Program 1 increases resolution to 6½ digits (see Section 5, Paragraph 5-7). As a systems DMM, resolution is determined by the conversion rate selected (see Section 6, Paragraph 6-68).

(C.) **IEEE-488 Bus Indicator** - Lights indicate the present status of the IEEE Bus.

(D.) **Input Terminals** - Separate connections for DCV, ACV and Ohms.

(E.) **Range Pushbuttons:**

First Function Level - In the DMM mode of operation, these seven momentary switches are used to select range. The annunciators indicate which range the instrument is on, and if it is in manual or AUTO ranging.

Second Function Level - The numbers (0 through 5) and the sign (-) are used for Front Panel Programs.

(F.) **Function Pushbuttons:**

First Function Level - In the DMM mode these 3 pushbuttons select either ohms or volts.

Second Function Level - The numbers (7,8, and 9) are used for Front Panel Programs.

(G.) **Zero Pushbutton:**

First Function Level - This button controls the internal zero program (see Paragraph 4-7). An illuminated annunciator indicates zero function is enabled.

Second Function Level - The number 6 is used for the Front Panel Programs.

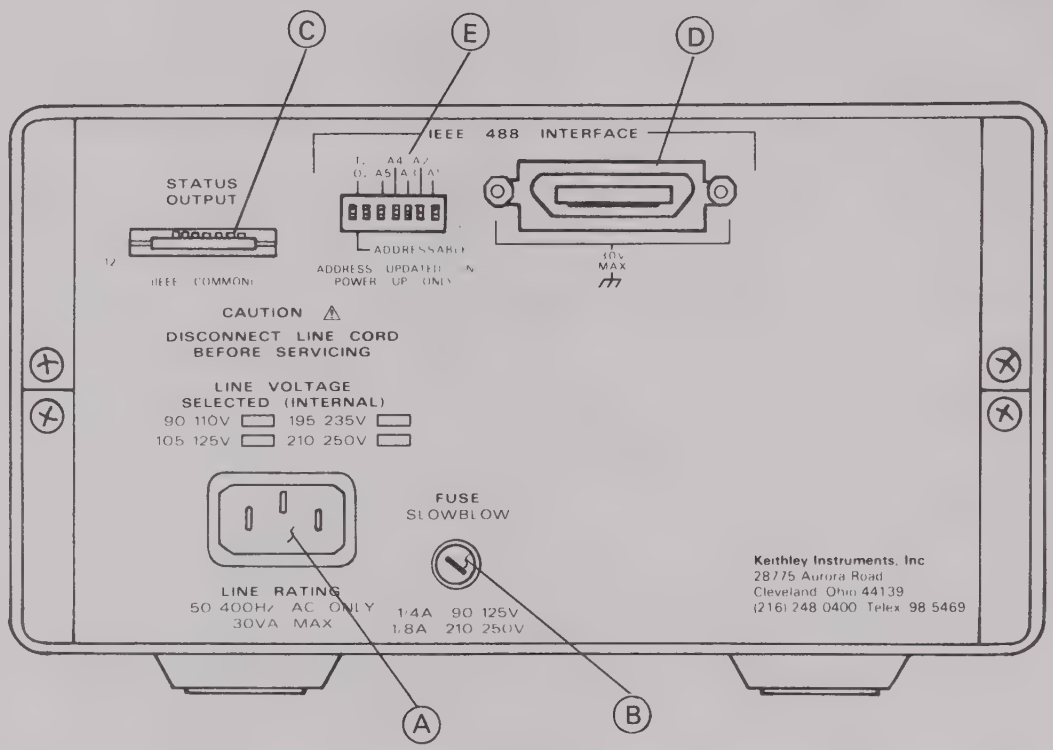
(H.) **Programming Pushbuttons:**

PRGM - This button calls Front Panel Programs.

RECALL - This is a first function level and displays the current program along with the data, if any.

ENT - This is a second function level and enters the selected data.

(I.) **Tilt Bail** - The tilt bail is used as a handle and to elevate the front of the instrument for better viewing.



REAR PANEL

3-3. REAR PANEL

3-4. The following information briefly describes the features of the 192 rear panel.

(A.) **Power Connector** - The instrument will operate on two voltage ranges of 50 to 400Hz AC power (see Section 1, Paragraph 1-40).

(B.) **Fuse** - See Section 2, Paragraph 2-4 for the proper fuse replacement.

(C.) **Status Output*** - This is an output for the Model 1924 Rear Input Adapter. Also, this output can be used to drive relays used for sorting and handling equipment.

(D.) **IEEE Connector*** - This is the IEEE connection to the Model 192.

(E.) **Programming Switches*** - These switches are used to program the 1923 IEEE option (see Section 6, Paragraph 6-7).

*These devices are present when the Model 1923 IEEE option is installed.

SECTION 4. BASIC DMM OPERATION

4-1. INTRODUCTION

4-2. This section describes procedures for connection and use of the Model 192.

4-3. POWER UP

4-4. Upon power up, the Model 192 displays the line frequency with the current software revision level. Range and function are set to 1200VDC. Line frequencies from 56.25Hz to 75Hz set the conversion rate to 16.67ms. If line frequencies are below or above those previously mentioned, the 192 is set 20ms conversion rate.

TABLE 4-1
LINE POWER REQUIREMENTS

LINE SWITCH SETTING	MINIMUM/ MAXIMUM LINE VOLTAGE	MINIMUM/ MAXIMUM LINE FREQUENCY
115V	105V/125V	50/400Hz
230V	210V/250V	50/400Hz

4-5. OPERATING INSTRUCTIONS

4-6. The basic operating instructions for the Model 192 are discussed in the following paragraphs. The front panel controls are straightforward and easy to use. The upper three binding posts are used for voltage input connections. The lower four binding posts are used for ohms connections. The "LO" binding posts for "ACV", "Ω, and "DCV" are wired together. The "LO" inputs may be floated at voltages up to 1.4kV or 5 x 10^5V•Hz. "DC" voltage sources, "AC" voltage sources and Ohms sources may be simultaneously connected to the input terminals with consideration for possible ground loops and noise.

WARNING

Safety hazards are present when floating input connections. To prevent possible safety hazards, disconnect floating voltages before making ohms measurements.

CAUTION

Do not exceed maximum input limits given in Table 4-2.

TABLE 4-2
MAXIMUM INPUT

FUNCTION	RANGE	MAXIMUM INPUT
DCV	All	1200V
ACV	All	1000V rms sine or DC, 2 x 10^7V•Hz
OHMS	All	360V peak or 250V rms

4-7. Zero

4-8. The "zero" control serves as a baseline suppression. When the zero control is enabled, the zero LED will light. All readings displayed while in the zero mode are the difference between the stored baseline and the actual voltage level. The zero control can be disabled by pressing the zero button.

The baseline obtained while the zero control is enabled represents a specific level or quantity of volts or ohms. For example, if 100mV is zeroed, then, 100mVDC represents the specific level of the zero baseline. One hundred millivolts will then be automatically subtracted from readings on any DCV range. The value for the baseline can be as little as a few microvolts or as large as 999 volts. This capacity enables the user to zero a wide range of voltages.

NOTE

Setting the range lower than the zero baseline value, will overrange the display.

4-9. One baseline can be stored for each of the functions (DC Volts, AC Volts and Ohms). For example, 20mVDC can be stored for DC volts, 10VAC can be stored for AC volts and 5Ω can be stored for ohms.

4-10. It is important to note that the use of zero reduces the dynamic range of measurement. For instance, if +1.00000VDC is the nulled value, input voltages greater than 2V would still overload the A/D converter (200,000 counts), even though overrange would occur at approximately 100,000 counts displayed. Readings less than -1V would cause overrange (2V less than +1V) because of the maximum display reading of -199,999 counts. This reduction in the dynamic range of the measurement is illustrated in Figure 4-1. In DCV function, both the display dynamic range and the input dynamic range can be exceeded and thus, both can limit the dynamic range of the measurement.

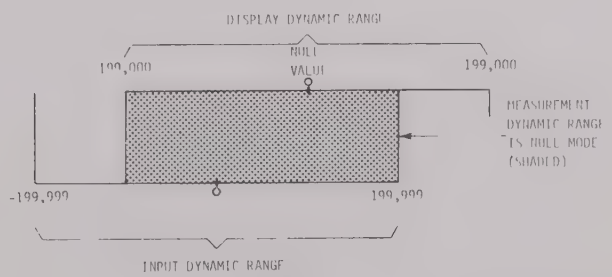


FIGURE 4-1
AFFECT OF NULL FUNCTION ON DYNAMIC RANGE OF MEASUREMENT

4-11. Overrange Indication

Overrange is indicated by "OFLO". If the overflow is negative, then a minus (-) prefix will appear before "OFLO".

4-12. FILTER

4-13. The Model 192 employs digital filtering techniques. There are three internal filter programs. Figure 4-2 shows the filter response curves.The internal computer automatically selects the filter. Filter "1" is selected on 5½-digit readings and filter "2" on 6½-digit readings.

When a large input change is sensed, the microprocessor disables the digital filter. This permits a fast response to the input (as noted by "A" in Figure 4-2). When the reading nears its final value, the filter is turned on (as noted by "B" in Figure 4-2). This permits low noise settling to the final value.

4-14. A third filter, filter "3" is available by the front panel program number two. filter modes "1", "2", and "3" can be programmed through the IEEE programming option. Filters are selected with conversion rate commands "SO" through "S8" (see Paragraph 6-68).

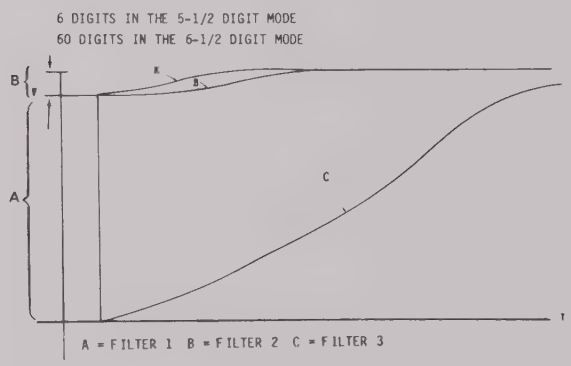
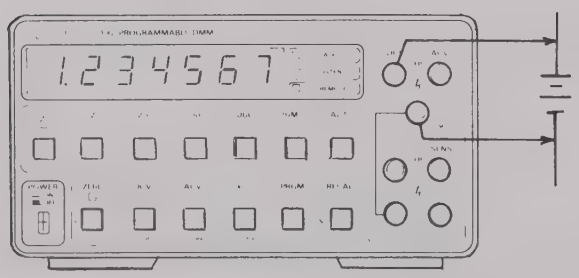


FIGURE 4-2
FILTER RESPONSE GRAPH

4-15. DC VOLTAGE MEASUREMENT



INPUT RESISTANCE:	1000MΩ .2V-20V 10MΩ 200V-1200V
SETTLING TIME:	250ms to within 6 digits at 5½ digits resolution
BENCH READING RATE:	8/sec. (6/sec. 50Hz)

4-16. The Model 192 reads DC voltages from below 10μV to 1200 volts. DC volts are measured as follows:

A. **TURN POWER ON** by pressing the power button. If the instrument is within 0°-50°C, it is useable immediately, but a 1-hour warmup is required to obtain rated accuracy.

B. **PRESS "DCV"**button.

C. **SELECT RANGE** from the five ranges available. The decimal point is positioned by the range pushbutton. The 1200V range is selected by the "2000" button.

D. **ZERO.** Short test leads and press "zero" button to cancel offsets when requiresd by the tes circuitry or if on the ".2V" range.

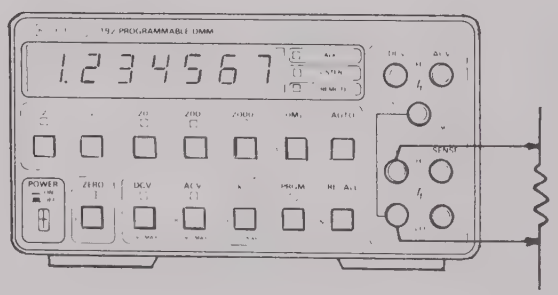
E. **CONNECT INPUT** between the "DCV" and "LO". The binding posts accept wires, spade lugs or banana plugs for ease of connecting the circuit to be measured. Low thermal cabling and connections are recommended for measurements on the 2μV range.

F. **TAKE READING** by observing the displayed digits and decimal point locations. All ranges are direct reading in volts.

G. On the .2V range, zero must be set with the "ZERO" function for rated accuracy. Zeroing is necessary to compensate for thermal EMFs generated by the connections to the circuit to be measured. These voltages may be only a few microvolts or several tens of microvolts. Set zero as follows:

1. Set the output of test circuit for zero volts or disconnect the test leads at the circuit and short them.
2. Set the Model 192 on the 200mV range.
3. Depress the ZERO pushbutton.
4. Reconnect the test leads and make the measurement by applying the signal and reading millivolts on the display
5. Make the measurement.

4-17. RESISTANCE MEASUREMENT



SETTLING TIME:	250ms to within 6 digits at 5½ digit resolution on .2k-2000kΩ Ranges; 500ms on 20mΩ Range
BENCH READING RATE:	8/s on .2k-2000kΩ range 4/s on 20MΩ range.

4-18. The Model 192 DMM measures resistance from 1mΩ/digit to 20MΩ. The Model 192 provides automatic 2-wire or 4-wire ohms operation. This means that if the ohms sense leads are connected, the measurement is automatically done 4-terminal. If the sense leads are not connected, the measurement is done 2-terminal. For 2-terminal or 4-terminal measurements on the .2kΩ range, zero must be set by the ZERO function to obtain rated accuracy. Use the Model 192 to measure resistance as follows:

A. **TURN ON POWER** by pressing power button.
B. **PRESS kΩ** button.
C. **SELECT RANGE** from the six ranges available (or autorange). The decimal point is positioned by the range pushbutton.
D. **ZERO.** For a 2-wire or 4-wire measurement on the .2kΩ range, zero must be set with the zero function to obtain rated accuracy. Zeroing is necessary to compensate for test lead resistance on 2-wire measurements and for thermal EMFs on 2- and 4-wire measurements. Set zero as follows:
   1. Disconnect the test leads at the circuit to be measured and short them.
   2. Depress the "ZERO" pushbutton.
   3. Reconnect the test leads and make the measurement.
E. **CONNECT INPUT** between "Ω" and "LO".
F. **MAKE READING.**

CAUTION

MAXIMUM ALLOWABLE INPUT VOLTAGE (all ranges): 360V peak, 250V rms. Do not exceed maximum voltage. Instrument damage may occur.

4-19. FOUR-TERMINAL OHMS MEASUREMENT

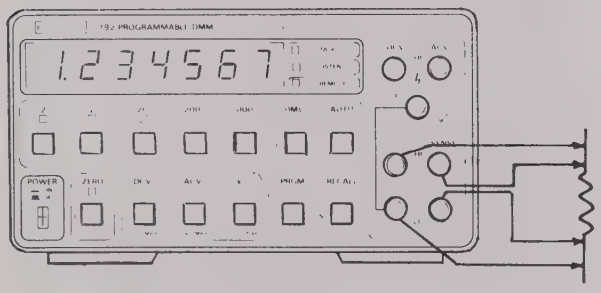


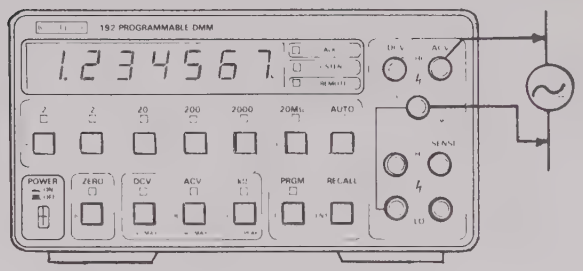
TABLE 4-3
FOUR TERMINAL TEST LEAD RESISTANCE

RANGE	LEAD RESISTANCE
.2k	7Ω
2k	22Ω
20k	70Ω
200k	220Ω
2000k	700Ω
20M	2200Ω

See Paragraph 4-18 for front panel operation.

4-20. For 4-terminal measurement connect the sense leads to the circuit to be measured and to the Ω SENSE terminals on the 192. This arrangement eliminates the error due to the voltage drop across the current-carrying leads. Accurate, high resolution ohms measurements are obtained using four terminal connections. Maximum test lead resistance for 4-terminal ohms measurements is given in Table 4-2.

4-21. AC VOLTAGE MEASUREMENT (1910 AC Option)



INPUT IMPEDANCE:2 MΩ shunted by less than 50pF
SETTLING TIME:Less than 1.3 seconds to within 0.05% of final reading
BENCH READING RATE:2/second

4-22. With the Model 1910 option, the Model 192 reads AC voltages from 1μV/digit to 1000 V. The instrument is average responding and displays the root mean square value of a sine wave with a frequency of 20Hz to 100kHz. Accuracy is specified for 1000 counts and above. The maximum reading is 199999. Overrange is indicated by OFLO. Maximum allowable input is 1000V rms or DC; 2×10^7V•Hz. Use the Model 192 to measure AC voltage as follows:

CAUTION

Do not exceed maximum allowable input voltage. Instrument damage may occur. Maximum input is both the voltage and voltage hertz product. If maximum rating are exceeded, instrument damage will occcur.

A. **TURN POWER ON** with ON/OFF pushbutton.

B. **PRESS** ACV button.

NOTE

The Model 192 will display "NO AC" if AC is selected without the 1910 AC option.

C. **SELECT RANGE** from the 4 ranges available. The decimal point is positioned by the range pushbutton. The 1200V range is selected with the 2000 button. If the 20MΩ button is inadvertently pressed when in ACV function, the 192 will set the range to 2000.
D. **ZERO OFF** unless measurements are to be made as deviations from a present value.

NOTE

Do not use ZERO to zero the range. A small residual zero reading is normal (approx. 200μV). If ZERO is used to zero, this residual voltage reading in specified accuracy range will be low by the amplitude of the zeroed residual voltage.

E. **CONNECT INPUT** to be measured between the INPUT HI and LO binding posts.
F. **TAKE READING.**

SECTION 5. FRONT PANEL PROGRAMS

5-1. INTRODUCTION

5-2. This section contains information and instructions for operating the eight internal programs of the 192.

5-3. Program Notes

A. When entering a number for any program:
   1. The decimal point is set automatically (usually according to the range).
   2. Prompting is done with a blinking "c" segment.
   3. All invalid keys are ignored.
   4. Trailing zeroes are automatically added.
   5. The display starts over with zero if too many digits are entered.

B. Program 0 is used to cancel all programs except Program 1 and 2.

C. Programs 1 and 2 can be used with any other program.

D. Programs 3 through 7 are mutually exclusive

E. New programs can be entered without going through-Program 0.

F. All constants for the programs are saved.

G. Programs 3 through 7 are terminated when the 192 receives an IEEE remote enable command. Programs 1 and 2 are unaffected.

5-4. PROGRAM 0. CLEAR

5-5. This program cancels Programs 3 through 7. Upon Power up, no program is active.

5-6. Operating Instructions:

A. **Press PRGM.** "PRO ?" is displayed.

B. **Press 0.** "PRO 0" is displayed for ½ second.

C. "CLR" is displayed for ½ second and the program LED is turned off.

D. Programs 3 through 7 are cancelled and the 192 starts displaying readings.

5-7. PROGRAM 1. RESOLUTION

5-8. This program toggles the display from 5½ to 6½ digits. It has no effect on the IEEE output, and can be used in programs 3 through 7 though readings will be missed. Upon power up, the sixth digit is off and can be used in programs 3 through 7 though readings will be missed.

5-9. Operating Instructions:

A. **Press PRGM.** "PRO ?" is displayed.

B. **Press 1.** "PRO 1" is displayed for ½ second.

C. If in the 5½ digit mode, "6.5d" is displayed for ½ second and the sixth digit is enabled.

D. If in 6½ digit mode, "5.5d" is displayed for ½ second and the sixth digit is disabled.

E. The 192 continues displaying readings.

5-10. PROGRAM 2. FILTER

5-11. This program turns the filter on or off. Upon power up, the filter is off.

5-12. Operating Instructions:

A. **Press PRGM.** "PRO ?" is displayed.

B. **Press 2.** "PRO 2" is displayed for ½ second.

C. If the filter was off "FL ON" is displayed for ½ second, and the filter is enabled.

D. If the filter was on, "FL OFF" is displayed for ½ second, and the filter is disabled.

E. The 192 continues displaying readings.

5-13. PROGRAM 3. OFFSET/SCALE

5-14. This program allows the user to multiply the zeroed, filtered reading (X) by a constant (S), add an offset (B), and display the result (Y). $Y = SX + B$. Upon power up, $S = 1$ and $B = 0$. RANGE, FUNCTION, and ZERO are locked out when in this program.

5-15. Operating Instructions:

A. Select function and range.

B. **Press PRGM.** "PRO ?" is displayed.

C. **Press 3.** "PRO 3" is displayed for ½ second, and the program LED goes on.

D. "S ?" is displayed for ½ second, then the old value of S is displayed.

E. To enter the old value **Press ENT.**

F. To enter a new value, **Enter the Number,** then **Press ENT.** $-1.999999 \leq S \leq 1.999999$.

G. After ENT is pressed, "B ?" is displayed for ½ second, then the old value of B is displayed.

H. To enter the old value, **Press ENT.**

I. To enter a new value, **Enter the Number,** then **Press ENT.** $-1999999 \leq B \leq 1999999$ with the decimal point set according to the range.

J. After ENT is pressed, the values of Y are displayed.

K. To enter new values for S and B **Press RECALL,** and refer to Step D of this program.

5-16. PROGRAM 4. % DEVIATION

5-17. This program allows the user to compute the percent deviation (Y) of the zeroed, filtered reading (X) from a nominal value (n). $Y = [(X-n)/n] \times 100$. Upon power up $n = 0$. RANGE, FUNCTION, and ZERO are locked out when in this program.

5-18. Operating Instructions:

A. Select function and range and zero the instrument if desired.

B. **Press PRGM.** "PRO ?" is displayed.

C. **Press 4.** "PRO 4" is displayed for ½ second, and the program LED goes on.

D. "n ?" is displayed for ½ second, then the old value of n is displayed.

E. To enter the old value **Press ENT.**

F. To enter a new value, **Enter the Number,** then **Press ENT.** $-1999999 \leq n \leq 1999999$ with the decimal point set according to the range.

G. After ENT is pressed, values of Y (percent deviation) are displayed.
$199.9999 \leq Y \leq -199.9999$. "OFLO" with the sign will be displayed if these limits are exceeded.

H. To enter new values for n, **Press RECALL** and refer to Step D of this program.

5-19. PROGRAM 5. MIN/MAX

5-20. This program takes minimum and maximum measurements. RANGE, FUNCTION, and ZERO are locked out when in this program.

5-21. Operating Instructions:

A. Select function and range and zero the instrument, if desired.
B. **Press PRGM.** "PRO ?" is displayed.
C. **Press 5.** "PRO 5" is displayed for ½ second, and the program LED goes on.
D. The display continues to show all readings. The minimum and maximum readings are stored.
E. To display the high and low readings, **Press RECALL.** "PRO 5" is displayed for ½ second. "LO P" is displayed for ½ second, and then the low peak reading is displayed.
F. **Press RECALL** again. "HI P is displayed for ½ second, and then the maximum high peak reading is displayed.
G. To continue the program with the same minimum and maximum values, **Press ENT.** The program will continue as in Step D of this program.
H. To restart the program, refer to Step B of this program.

5-22. PROGRAM 6. HI/LO/PASS

5-23. This program allows the user to set the high and low limits into memory. Thus, each measurement is compared to these limits and the display will show HI, PASS, or LO. RANGE, FUNCTION, and ZERO are locked out when in this program. With the installation of the Model 1923 IEEE bus, outputs are available to drive relays for handling and sorting equipment.

5-24. Operating Instructions:

A. Select function and range.
B. **Press PRGM.** "PRO ?" is displayed.
C. **Press 6.**"PRO 6" is displayed for ½ second, and the program LED goes on.
D. "LO L?" is displayed for ½ second, then the old value of LO L is displayed.
E. To enter the old value, **Press ENT.**
F. To enter a new value, **Enter the Number**, then **Press ENT.** $-1999999 < LO < 1999999$ with the decimal point set according to the range.
G. After ENT is pressed, "HI L?" is displayed for ½ second,then the old value of HI L is displayed.
H. To enter the old value, **Press ENT.**
I. To enter a new value, **Enter the number**, then **Press ENT.** $-1999999 < HI < 1999999$ with the decimal point set according to the range. HI L must be greater than or equal to LO L or a new value for LO L will be requested as in Step D of this program.
J. After ENT is pressed, HI, PASS, or LO is displayed according to the following:
   1. If $X <$ LO L, then "LO " is displayed.
   2. IF $X >$ HI L, then "HI " is displayed.
   3. Otherwise, "PASS" is displayed.

   Three open collector outputs are available on the IEEE card for HI, PASS, and LO.
K. To enter new values for LO L and HI L **Press RECALL** and refer to Step D of this program.

5-25. PROGRAM 7. DATA LOGGER

5-26. This is the data logging mode. The logging rate can be programmed. The first 100 data points can be stored in the buffer. RANGE, FUNCTION, and ZERO are locked out when in this program.

5-27. Operating Instructions:

A. Select function and range.
B. **Press PRGM.** "PRO ?" is displayed.
C. **Press 7.** "PRO 7" is displayed for ½ second, and the program LED goes on.
D. "r = ?" is displayed for ½ second, then "r = *" is displayed where * is the old value of r, and t is the time interval between logged data points. r equals zero upon power up.

r	t	TOTAL TIME FOR 100 DATA POINTS
0	.11 sec/ .126 sec.	11 sec. at 60Hz/ 12.6 sec. at 50Hz
1	.5 sec.	50 sec.
2	1 sec.	1 min. 40 sec.
3	5 sec.	8 min. 20 sec.
4	10 sec.	16 min. 40 sec.
5	1 min.	1 hr. 40 min.
6	5 min.	8 hr. 20 min.
7	10 min.	16 hr. 40 min.
8	30 min.	2 days 2 hr.
9	1 hr.	4 days 4 hr.

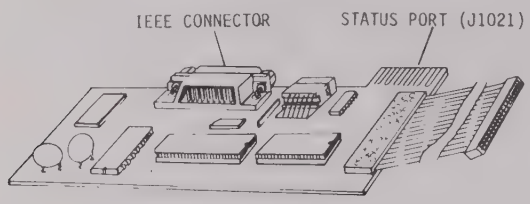
E. To enter the old value, **Press ENT.**
F. To enter a new value, **Enter the number**, then **Press ENT.**
G. After ENT is pressed, the 192 will display readings, but none will be logged. "Enter" is displayed periodically to indicate that a trigger is needed.
H. **Press ENT** again to start logging data points. "B Full" is displayed when all 100 data points are logged. This indicates that the buffer is full.
I. The program LED will flash again at a fixed rate when all 100 data points are logged.
J. To stop the logging process and retrieve the data points at any time, **Press RECALL.** The display will show "N = *" for ½ second, and then show the last data point stored. The asterisk (*) is equal to the number of the last data point stored.
K. **Pressing RECALL,** after the last data point has been displayed, will cause the first data point to be displayed.
L. **Press RECALL** again for the next data point, and so on. Holding the button in will automatically increment readings.
M. To display the previous data points **Press -,** then **Press ENT.** If pressed when the first data point is displayed, then the last data point is displayed.
N. **Pressing RECALL** again will display previous data points until minus is entered again.
O. To continue logging data, **Press 0,** and then **Press ENT.** The data logging process will continue from the last logged data point.
P. To change the rate refer to Step B of this program.

SECTION 6. SYSTEM OPERATION

6-1. INTRODUCTION

6-2. This section contains information and instructions for remote operation of the Model 192.

The Model 192 can be interfaced to an IEEE Standard Bus, using the Model 1923 IEEE Interface option.



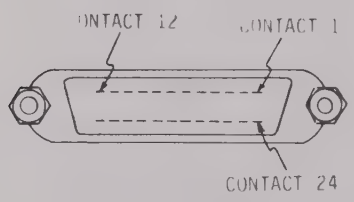
MODEL 1923 IEEE OPTION

The Model 1923 may be either factory or field installed (see Section 2, Paragraph 2-8 for installation instructions).

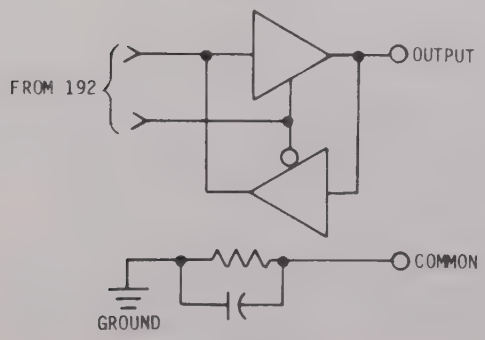
Pinouts for the IEEE and for the "Status Port" are as follows:

IEEE - CONNECTOR PIN ASSIGNMENTS

Contact	Signal Line	Contact	Signal Line
1	D101	13	D105
2	D102	14	D106
3	D103	15	D107
4	D104	16	D108
5	EOI	17	REN
6	DAV	18	Gnd, (6)
7	NRFD	19	Gnd, (7)
8	NDAC	20	Gnd, (8)
9	IFC	21	Gnd, (9)
10	SRQ	22	Gnd, (10)
11	ATN	23	Gnd, (11)
12	SHIELD	24	Gnd, LOGIC



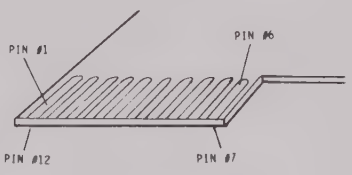
IEEE CONNECTOR



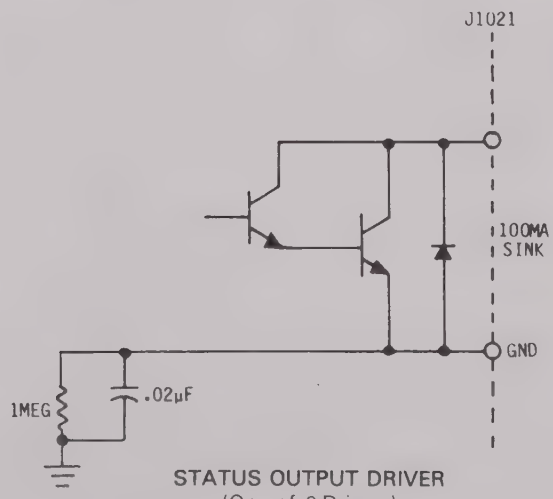
IEEE BUS DRIVER
(One of 16 Drivers)

"STATUS PORT" PIN ASSIGNMENTS

CONTACT	SIGNAL LINE
1	Not Used
2	Not Used
3	HIGH (Pass Low High)
4	PASS (Pass Low High)
5	LOW (Pass Low High)
6	+5V
7	COMMON
8	DCV
9	ACV
10	Ohms
11	Not Used
12	Not Used



STATUS OUTPUT



STATUS OUTPUT DRIVER
(One of 6 Drivers)

6-3. SYSTEM ASSEMBLY

6-4. System assembly consists of connecting the Model 192 to the IEEE bus. Additional instruments may be connected to the bus depending on the mode of operation. IEEE cables are available from Keithley Instruments in six foot lengths (Model 7008). These cables are IEEE compatible. Cabling is limited to 15 devices on a single contiguous bus. Bus length must not exceed 20 meters.

6-5. The IEEE port can be set up in one of two modes. It can be set up in the "TALK ONLY" mode to continuously output data, or it can be set up in an "ADDRESSABLE" mode to receive and transmit data from an external controller. The internal programs of the Model 192 are not controllable over

the IEEE Bus. If the Model 192 is in the "PROGRAM" mode, then any IEEE commands will cause the programs to be terminated.

6-6. The 192 has separate input connectors for DCV, ACV and Ohms. However, the Model 1924 Rear Input Adapter is available as an option for single or multiple input systems.

6-7. Switch Programming

6-8. The rear panel programming switches on the 192 allow the user to program the IEEE option for the Talk Only or the Addressable mode of operation. The programming switches are read only on power up. If switch settings are changed, the instrument power must be cycled.

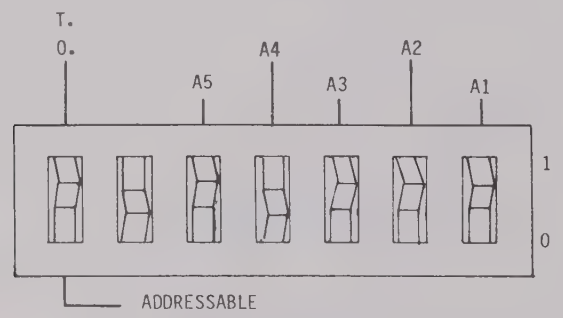


FIGURE 6-1
IEEE PROGRAMMING SWITCHES

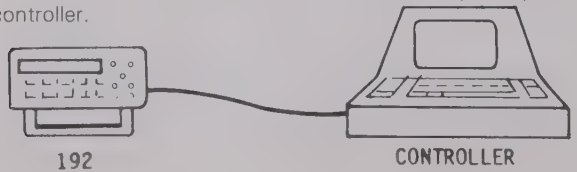
6-9. Talk Only

6-10. In the Talk Only mode the 192 can send data to a listener, such as a printer, without the use of a controller.

6-11. The talker on the IEEE Bus may be interfaced with one or more listeners. The quantity of listeners, data format and cabling conform to IEEE standards. This allows the 192 to be used with a wide variety of IEEE-comaptible listeners. In the "TALK ONLY" mode, data is sent out and the 192 waits for a "data received" response from the listener. It should be noted that the 192, when programmed in the "TALK ONLY" mode, will hang up if no response is received from the listener. The response from the listener may be delayed to control the rate of data transfer between the 192 and the listener. To set the 192 to the "TALK ONLY" function, locate the rear panel programming switches. Set the "T.O.". switch to T.O. (see Figure 6-1). In the "TALK ONLY" mode, the address switches are not used.

6-12. Addressable

6-13. In the Addressable mode the 192 can send or receive data over the IEEE bus when addressed by a systems controller.



The Controller on the IEEE Bus may be interfaced with one or more instruments. Each instrument on the bus must have a unique address. The quantity of listeners, data format and cabling conform to IEEE Standards. This allows the 192 in the "ADDRESSABLE" mode to be used with all IEEE compatible controllers. The 192 must be programmed to the "ADDRESSABLE" mode and with the "DEVICE" address. To program the "ADDRESSABLE" function, locate the rear panel programming switches and set the "T.O." switch to the "ADDRESSABLE" position. Address selection is programmed via the rear panel switches. Any address between one and thirty may be programmed. The switches arebinary weighted. LSB is Switch No. 1 and MSB is Switch No. 5.

NOTE

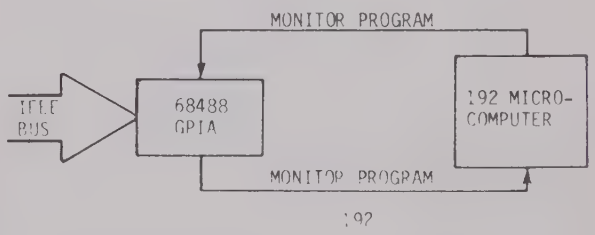
Switches are set at the factory for Address 8.

6-14. After the hardware is assembled, the software has to be assembled. The customer should confirm that his controller has the appropriate handler software for the IEEE port.

6-15. USING IEEE COMMANDS

6-16. This section describes what happens when the 192 receives various IEEE commands. IEEE commands are grouped, and all commands within the group are listed in Table 6-1. Definitions are given for command groups and for individual commands within the group. In addition, a flow chart is included with individual commands.

IEEE programming of the 192 is accomplished through the IEEE interface option. This interface connects the internal computer of the 192 with the IEEE bus. Information through the interface is handled by a 40-pin integrated circuit, A 68488, General Purpose Interface Adapter (GPIA).



For example, if a Device Clear "DCL" is placed on the bus by a controller, then the 192 software will branch to a "DCL" handler routine (see Figure 6-2).

If an "IFC" is placed on the bus, the 192 Software Program will branch into the "IFC" handler routine.

The following text, in general terms, describes these handler routines. By using flow charts of the handler routines, the programmer can learn what happens when the Model 192 receives a command.

In addition to flow charts, a brief description of the command is given.

Some commands, when placed on the bus, will not cause the monitor of the 192 to branch. These commands require a previous condition to be met before the 192 will respond.

Commands on the following pages are grouped according to the special conditions regarding their use (See Table 6-1). There are six groups. Each group performs a specific function under a specific condition. A description is given for each of the six groups.

6-17. HANDSHAKE COMMAND GROUP

6-18. Handshake commands control the data transfer over the bus.

6-19. DAC: Data Accepted

6-20. Data Accepted is a uniline (single wire) command or signal. A data accepted signal is an acknowledgment from an addressed listener, indicating the listener has received data.

6-21. RFD: Ready For Data

6-22. Ready For Data is a uniline (single wire) command or signal. A ready for data signal is an acknowledgment from data acceptor(s) indicating the acceptor is prepared to receive data.

6-23. DAV: Data Valid

6-24. The Data Valid line is asserted low (true) by a talker after it places its data on the bus. This tells the listener that the data on the bus is valid.

6-25. UNIVERSAL COMMAND GROUP

6-26. Universal Commands are a set of commands that are obeyed by all devices capable of responding, whether or not they are addressed.

6-27. DCL: Device Clear (see Figure 6-3)

6-28. This command simultaneously clears all instruments capable of responding to a DCL command. Instruments are returned to their initialized states.

INITIALIZED STATES (Model 192):

S3 16.667 mS Integration Time
Q0 Buffer No Readings
F0 DC Volts
R5 1,000 Volt Range
Z0 Front Panel Zero Off
T0 Continuous On Talk
Y Terminator is (CR)(LF)
K0 EOI With Last Byte
M0 Non SRQ Mode
W1 Delay On

6-29. IFC: Interface Clear (see Figure 6-4)

6-30. This command simultaneously disables ADDRESSABLE functions of all instruments capable of responding to an "IFC" command. The Model 192 is put in a Talk/Listen idle state.

NOTE

"IFC" only excludes the 192 from responding to an Addressable command. All other previously programmed functions are unaffected.

TABLE 6-1
IEEE COMMAND GROUPS

HANDSHAKE COMMAND GROUP

DAC = DATA ACCEPTED
RFD = READY FOR DATA
DAV = DATA VALID

UNIVERSAL COMMAND GROUP

ATN = ATTENTION
DCL = DEVICE CLEAR
IFC = INTERFACE CLEAR
LLO = LOCAL LOCK OUT
REN = REMOTE ENABLE
SPD = SERIAL POLL DISABLE
SPE = SERIAL POLL ENABLE

ADDRESS COMMAND GROUP

LISTEN: LAG = LISTEN ADDRESS GROUP
MLA = MY LISTEN ADDRESS
UNL = UNLISTEN
TALK: TAG = TALK ADDRESS GROUP
MTA = MY TALK ADDRESS
UNT = UNTALK
OTA = OTHER TALK ADDRESS

ADDRESSABLE COMMAND GROUP

ACG = ADDRESSED COMMAND GROUP
GET = GROUP EXECUTE TRIGGER
GTL = GO TO LOCAL
SDC = SELECTED DEVICE CLEAR

DEVICE DEPENDENT COMMAND GROUP

FUNCTION: F0 = DCV; F1 = ACV; F2 = kΩ
RANGE: R0 = AUTO; R1 = 0.2; R2 = 2; R3 = 20; R4 = 200; R5 = 2000; R6 = 20M (Ω only)
ZERO: Z0 = OFF; Z1 = ON
TRIGGER: T0 = CONT. ON TLK; T1 = ONE SHOT ON TLK; T2 = CONT. ON GET; T3 = ONE SHOT ON GET; T4 = CONT. ON X; T5 = ONE SHOT ON X
X = EXECUTE
U = Send status bytes. Sequence is T F R K Q S M Y Z W.
RATE: S0 = 4ms INTEGRATION (4½d); S1 = LINE CYCLE INTEGRATION (5½d); S2 = LINE CYCLE INTEGRATION WITH FILTER 1 (5½d); S3 = LINE CYCLE INTEGRATION WITH FILTER 2 (6½d); S4 = LINE CYCLE INTEGRATION WITH FILTER 3 (6½d); S5 = 100ms INTEGRATION (5½d); S6 = 100ms INTEGRATION WITH FILTER 1 (5½d); S7 = 100ms INTEGRATION WITH FILTER 2 (6½d); S8 = 100ms INTEGRATION WITH FILTER 3 (6½d)
DELAY: W0 = 0; W1 = 10ms
BUFFER: Q0 = CLEAR; Q1 = STORE 100 READINGS
MODE: M0 = SRQ OFF; M1 = SRQ ON
EOI: K0 = SEND; K1 = DO NOT SEND
TERMINATOR: Y(LF) = CR LF; Y(CR) = LF CR; Y( ) = ANY ASCII; Y(DEL) = NONE

STATUS COMMAND GROUP

RQS = REQUEST SERVICE
SRQ = SERIAL POLL REQUEST
STB = STATUS BYTE

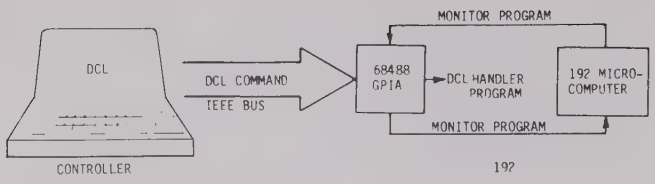


FIGURE 6-2
SENDING A DCL COMMAND

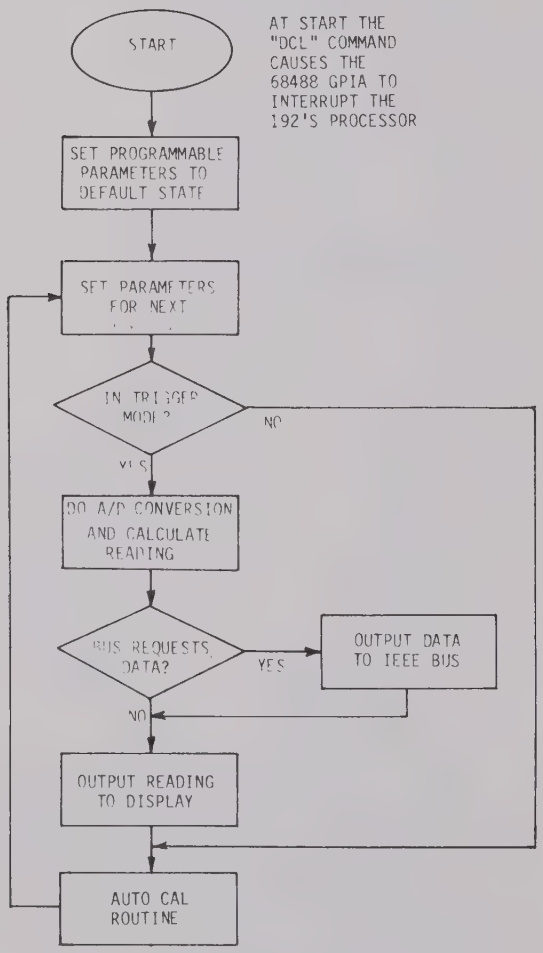


FIGURE 6-3
DCL COMMAND

6-31. LLO: Local Lock Out (see Figure 6-5)

6-32. This command simultaneously disables front panel programming capabilities on all instruments capable of responding to a "LLO" command.

NOTE

Previously programmed functions of the 192 are unaffected. After a "LLO" command, the controller can change the 192 functions by placing the desired command on the bus.

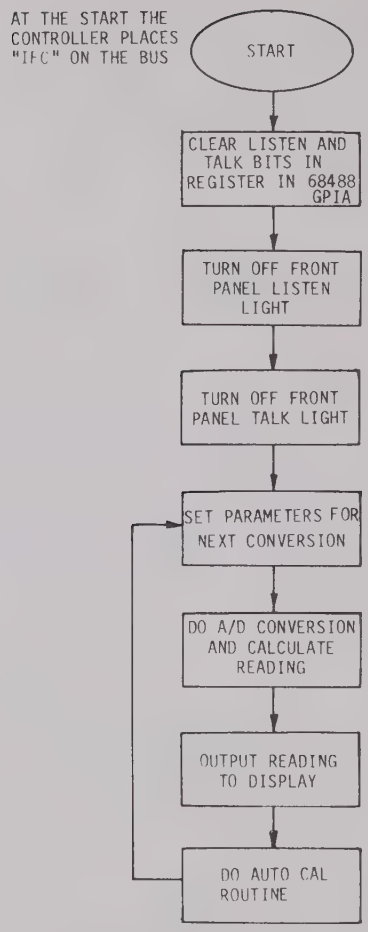

AT THE START THE CONTROLLER PLACES "IFC" ON THE BUS
START
CLEAR LISTEN AND TALK BITS IN REGISTER IN 68488 GPIA
TURN OFF FRONT PANEL LISTEN LIGHT
TURN OFF FRONT PANEL TALK LIGHT
SET PARAMETERS FOR NEXT CONVERSION
DO A/D CONVERSION AND CALCULATE READING
OUTPUT READING TO DISPLAY
DO AUTO CAL ROUTINE

FIGURE 6-4
IFC COMMAND

6-33. REN: Remote Enable (see Figure 6-6)

6-34. This command simultaneously enables the remote programming function of all instruments capable of responding to a "REN" command.

NOTE

All other previously programmed functions of the 192 are unaffected.

6-35. SPE: Serial Poll Enable
SPD: Serial Poll Disable
(see Figure 6-7)

6-36. These commands are used to learn the status of all instruments connected to the bus. All instruments capable of serial polling are simultaneously put into the serial poll mode by the "SPE" command. The Model 192 is capable of serial polling. Once in the serial poll mode, the controller addresses each instrument. When an instrument receives its TALK address, then status from that instrument will be placed on the bus. The controller continues addressing other instruments and collects status from them. When status is collected from all instruments, the controller places "SPD" on the bus. This command simultaneously disables the serial poll function from all instruments.

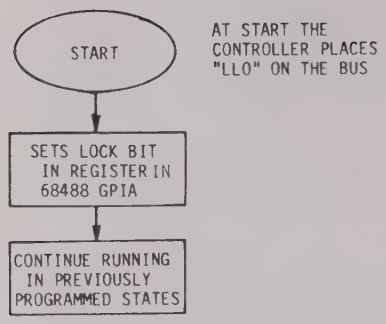

START
AT START THE CONTROLLER PLACES "LLO" ON THE BUS
SETS LOCK BIT IN REGISTER IN 68488 GPIA
CONTINUE RUNNING IN PREVIOUSLY PROGRAMMED STATES

FIGURE 6-5
LLO COMMAND

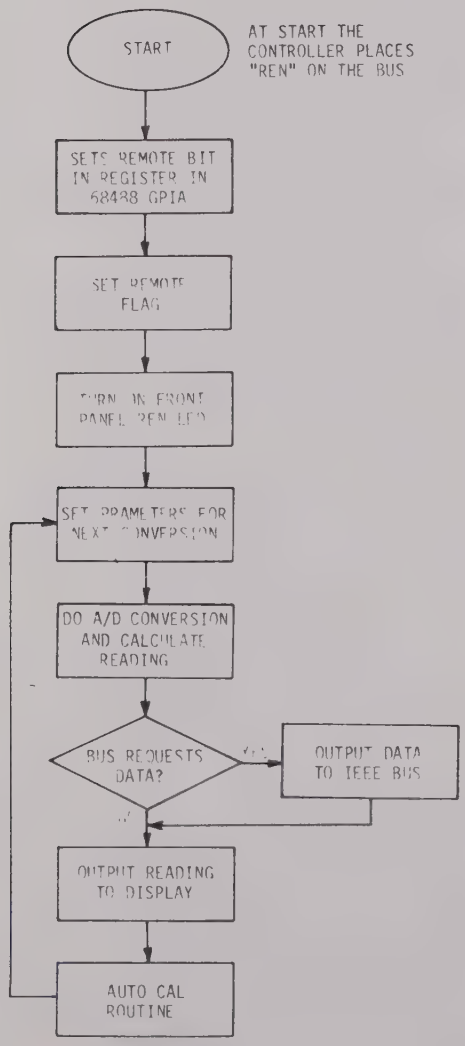

START
AT START THE CONTROLLER PLACES "REN" ON THE BUS
SETS REMOTE BIT IN REGISTER IN 68488 GPIA
SET REMOTE FLAG
TURN IN FRONT PANEL REN LED
SET PARAMETERS FOR NEXT CONVERSION
DO A/D CONVERSION AND CALCULATE READING
BUS REQUESTS DATA?
YES
NO
OUTPUT DATA TO IEEE BUS
OUTPUT READING TO DISPLAY
AUTO CAL ROUTINE

FIGURE 6-6
REN COMMAND

6-37. ADDRESS COMMAND GROUP

6-38. An address command selects an instrument on the bus. Only one address at a time can be placed on the bus.

6-39. UNL: Unlisten (see Figure 6-8)

6-40. An unlisten command removes all addressed listeners from the IEEE bus.

NOTE

"UNL" programs the Model 192 to the listener idle state. All other previously programmed functions are unaffected

6-41. UNT: Untalk (see Figure 6-9)

6-42. An untalk command removes all addressed "Talkers" from the IEEE bus.

NOTE

"UNT" only excludes the 192 from responding to a talk command. All other previously programmed functions are unaffected.

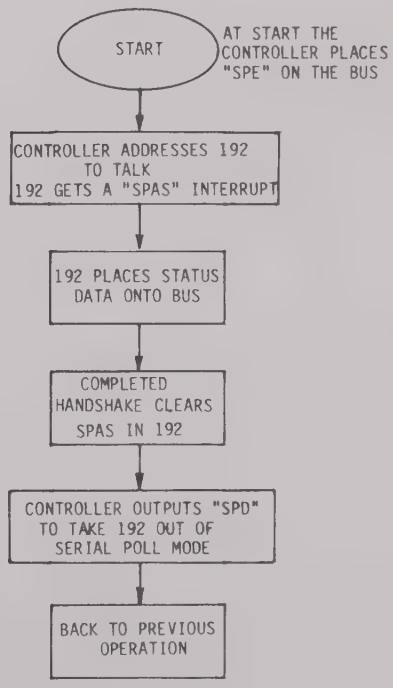

START
AT START THE CONTROLLER PLACES "SPE" ON THE BUS
CONTROLLER ADDRESSES 192 TO TALK
192 GETS A "SPAS" INTERRUPT
192 PLACES STATUS DATA ONTO BUS
COMPLETED HANDSHAKE CLEARS SPAS IN 192
CONTROLLER OUTPUTS "SPD" TO TAKE 192 OUT OF SERIAL POLL MODE
BACK TO PREVIOUS OPERATION

FIGURE 6-7
SPE COMMAND

6-43. ADDRESSABLE COMMAND GROUP

6-44. These commands are obeyed by devices which have been addressed as listeners. For the following commands to be programmed, the individual instrument must be previously addressed to listen.

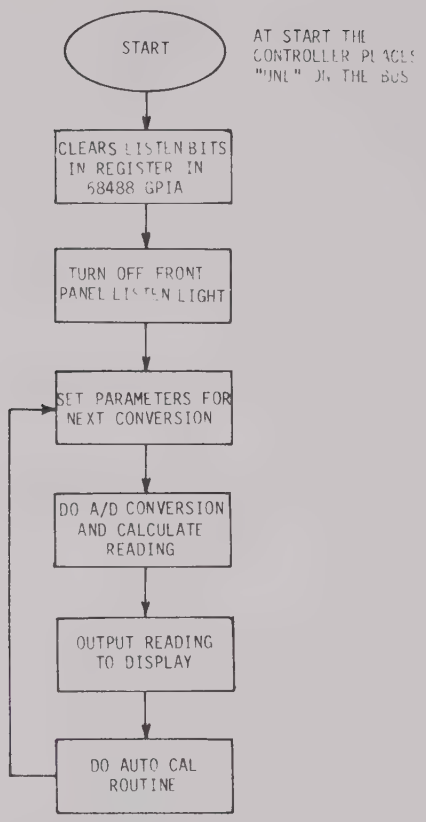

START
AT START THE CONTROLLER PLACES "UNL" ON THE BUS
CLEARS LISTEN BITS IN REGISTER IN 68488 GPIA
TURN OFF FRONT PANEL LISTEN LIGHT
SET PARAMETERS FOR NEXT CONVERSION
DO A/D CONVERSION AND CALCULATE READING
OUTPUT READING TO DISPLAY
DO AUTO CAL ROUTINE

FIGURE 6-8
UNL COMMAND

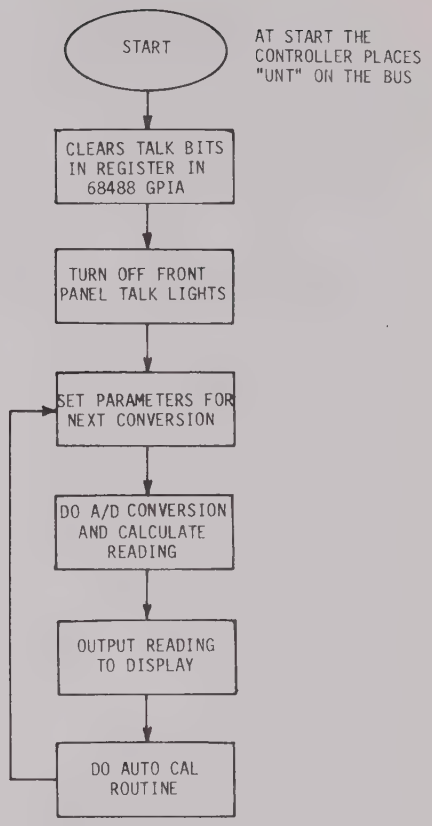

START
AT START THE CONTROLLER PLACES "UNT" ON THE BUS
CLEARS TALK BITS IN REGISTER IN 68488 GPIA
TURN OFF FRONT PANEL TALK LIGHTS
SET PARAMETERS FOR NEXT CONVERSION
DO A/D CONVERSION AND CALCULATE READING
OUTPUT READING TO DISPLAY
DO AUTO CAL ROUTINE

FIGURE 6-9
UNT COMMAND

6-45. GET: Group Execute Trigger (see Figure 6-10)

6-46. Some systems could include instruments whose functions you may desire to execute at the same time. "GET" triggers one or more devices specified as listeners to function simultaneously. The flow chart shows how the 192 responds to a "GET" command. T2 and T3 are examples of trigger modes.

NOTE

The 192 stays in one of these loops until it is reprogrammed.

6-47. GTL: Go To Local (see Figure 6-11)

6-48. This command allows the user to return control of an instrument to front panel controls.

NOTE

"GTL" only excludes the 192 from remote programming - all other previously programmed functions are unaffected.

6-49. SDC: Selected Device Clear (see Figure 6-12)

6-50. This command clears a single addressed instrument. The instrument is returned to its initialized state.

INITIALIZED STATES: (Model 192):

S3 16.667 mS Conversion Time
Q0 Buffer, No Readings
F0 DC Volts
R5 1,000 Volt Range
Z0 Front Panel Zero Off
T0 Continuous On Talk
Y Terminator Is (CR)(LF)
K0 EOI With Last Byte
M0 Non SRQ Mode
W1 Delay On

6-51. DEVICE DEPENDENT COMMAND GROUP (see Figure 6-13)

6-52. These are instrument programmming commands. Commands within this group are specified by the instrument(s). All device dependent commands must be followed by a terminator (X) to be acted upon by the Model 192.

All device dependent commands are processed in a similar manner in the 192. The programmer has the option of sending single or multiple device dependent commands. Only those parameters programmed are changed.

Single Command R1X
Multiple Command R1T0F1X

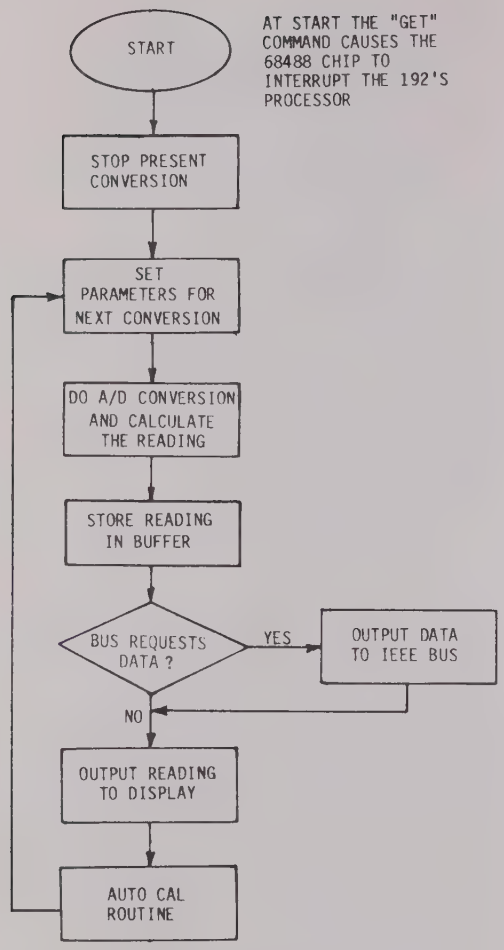

START
AT START THE "GET" COMMAND CAUSES THE 68488 CHIP TO INTERRUPT THE 192'S PROCESSOR
STOP PRESENT CONVERSION
SET PARAMETERS FOR NEXT CONVERSION
DO A/D CONVERSION AND CALCULATE THE READING
STORE READING IN BUFFER
BUS REQUESTS DATA ?
YES
OUTPUT DATA TO IEEE BUS
NO
OUTPUT READING TO DISPLAY
AUTO CAL ROUTINE

FIGURE 6-10
GET COMMAND

6-53. Function Command

6-54. This feature is useful when it is desirable to change only a single Device Dependent Command.

6-55. A function command places the 192 in one of the following modes:

F0 = DC Volts
F1 = AC Volts
F2 = Ohms

6-56. Range Command

6-57. A range command selects the appropriate range as shown below:

RANGE	DCV	ACV	OHMS
R0	Auto	Auto	Auto
R1	0.20V	0.20V	0.20k
R2	2.00V	2.00V	2.00k
R3	20.0V	20.0V	20.0k
R4	200V	200V	200k
R5	1200V	1200	2000k
R6	*	*	20M

* = Illegal ranges

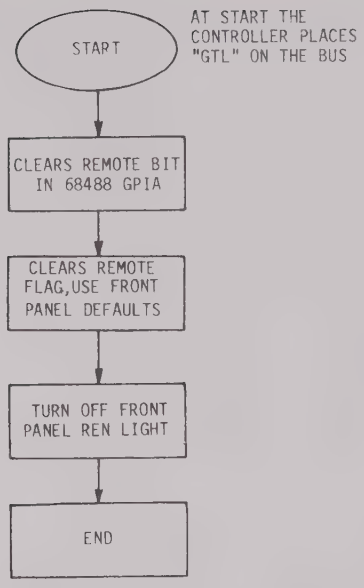

START
AT START THE CONTROLLER PLACES "GTL" ON THE BUS
CLEARS REMOTE BIT IN 68488 GPIA
CLEARS REMOTE FLAG,USE FRONT PANEL DEFAULTS
TURN OFF FRONT PANEL REN LIGHT
END

FIGURE 6-11
GTL COMMAND

6-58. An R6 command is a nonexistent range on "AC" or "DC" volts. An R6 command, under the conditions above, will stop the Model 192 from receiving additional commands. Clearing a nonexistent or illegal "R6" command is done by entering the appropriate range command (R1-R5).

6-59. Zero Command

6-60. Z0 = Front panel zero off
Z1 = Front panel zero on

A zero command serves as a baseline suppression. When a zero command is given, the zero LED will light. All readings displayed while in the zero mode are the difference between the stored baseline and the actual voltage level. The zero function can be disabled by pressing entering "Z0".

The baseline obtained while the function is enabled represents a specific level or quantity of volts or ohms. For example, if 100mV is zeroed, then, 100mVDC represents the specific level of the zero baseline. One hundred millivolts will then be automatically subtracted from readings on any DCV range. The value for the baseline can be as little as a few microvolts or as large as full scale. This capacity enables the user to zero a wide range of voltages.

NOTE

Setting the range lower than the zero baseline value, will overrange the display.

6-61. One baseline can be stored for each of the functions (DC volts, AC volts and Ohms). For example, 20mVDC can be stored for DC volts, 10VAC for AC volts and 5Ω for Ohms.

6-62. It is important to note that the use of zero reduces the dynamic range of measurement. For instance, if +1.00000VDC is the nulled value, input volages greater than 2V would still overload the A/D converter (200,000 counts), even though overrange would occur at 100,000 counts displayed. Readings less than -1V would cause overrange (2V

less than +1V) because of the maximum display reading of -199,999 counts. This reduction in the dynamic range of the measurement is illustrated in Section 4, Paragraph 4-10. In any volt or ohm function, the display dynamic range and the input dynamic range can be exceeded and thus, both can limit the dynamic range of the measurement.

6-63. Trigger Command

6-64. Trigger commands are selected when a reading(s) is triggered. All triggered readings follow the same sequence of events, as shown on the flow chart (see Figure 6-12).

TRIGGGER MODES

T0 - Continuous on TALK/Power Up
The unit will update the output data buffer at the display rate after being addressed to TALK.

T1 - One shot on TALK
Same as above, but triggers a single reading when addressed to TALK.

T2 - Continuous on GET
Same as "T0", but triggers on GET.

T3 - One shot on GET
Same as "T1", but triggers on GET.

T4 - Continuous on X
Same as "T0" , but triggers on "X".

T5 - One shot on "X"
Same as "T1", but triggers on "X".

6-65. Data Store Command

6-66. The Data Store command enables the internal storage buffer in the Model 192.

Q0: Clears buffer by placing "empty" in the buffer for each reading and then turns the buffer off.

Q1: Loads buffer after trigger with 100 readings; depending on trigger mode.

Each time a reading is trigggered, a reading is placed into the buffer. The rate at which the buffer is loaded can be controlled by various device dependent commands.

6-67. OPERATION NOTES:

A. Filling the buffer
1. In one shot modes, one reading is stored after each trigger.
2. In continuous modes, buffer fills using internal rate.

B. Emptying the buffer
1. On buffer full, SRQ generated if in M1 mode.
2. On buffer full, display message "BUF F" for 2 seconds.
3. Reading the buffer starts at loc 1, next loc 2 etc. (do not have to read all 100 to continue; if another trigger is given, buffer starts filling at next location until the end).
4. Data read out is in standard form, i.e. NDCV...
5. Readings will be maintained in the buffer as long as power is applied to the 192, or until a "Q0" or "Q1" is again given to initialize or restart the buffer.
6. Q0 turns off the buffer.
7. Issue another "Q1" to restart the buffer.

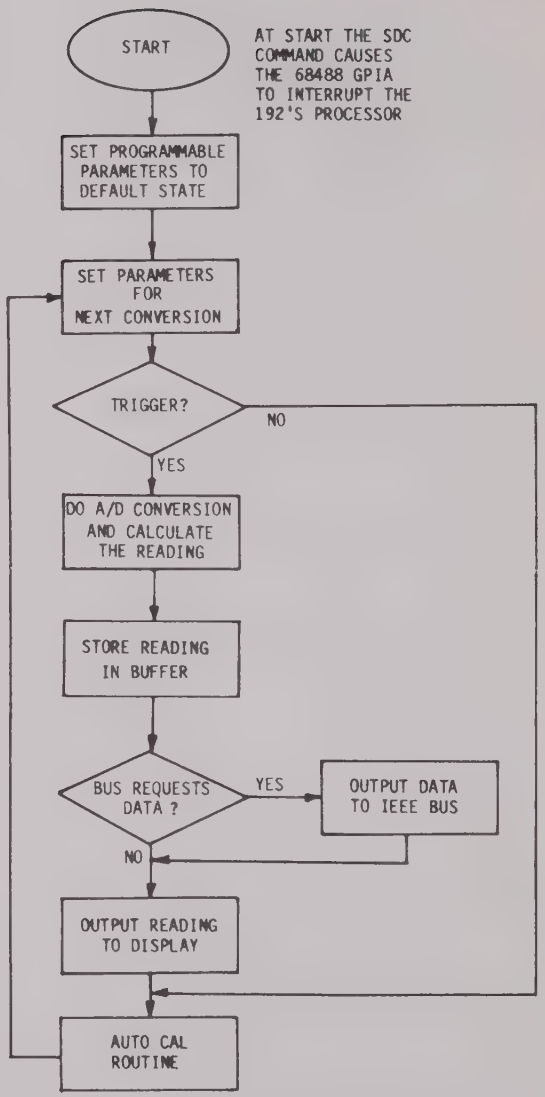


FIGURE 6-12
SDC COMMAND

6-68. Conversion Rate Command

6-69. A conversion rate command enables the programmer to select the speed resolution trade off required for his particular application (see Table 6-1, Device Dependent Command Group - Conversion Rate).

	INTEGRATION PERIOD	DIGITS	FILTER
S0	4	4½	
S1	16.66 (20ms, 50Hz)	5½	
S2	16.66 (20ms, 50Hz)	6½	Filter 1
S3	16.66 (20ms, 50Hz)	6½	Filter 2
S4	16.66 (20ms, 50Hz)	6½	Filter 3
S5	100	5½	
S6	100	5½	Filter 1
S7	100	6½	Filter 2
S8	100	6½	Filter 3

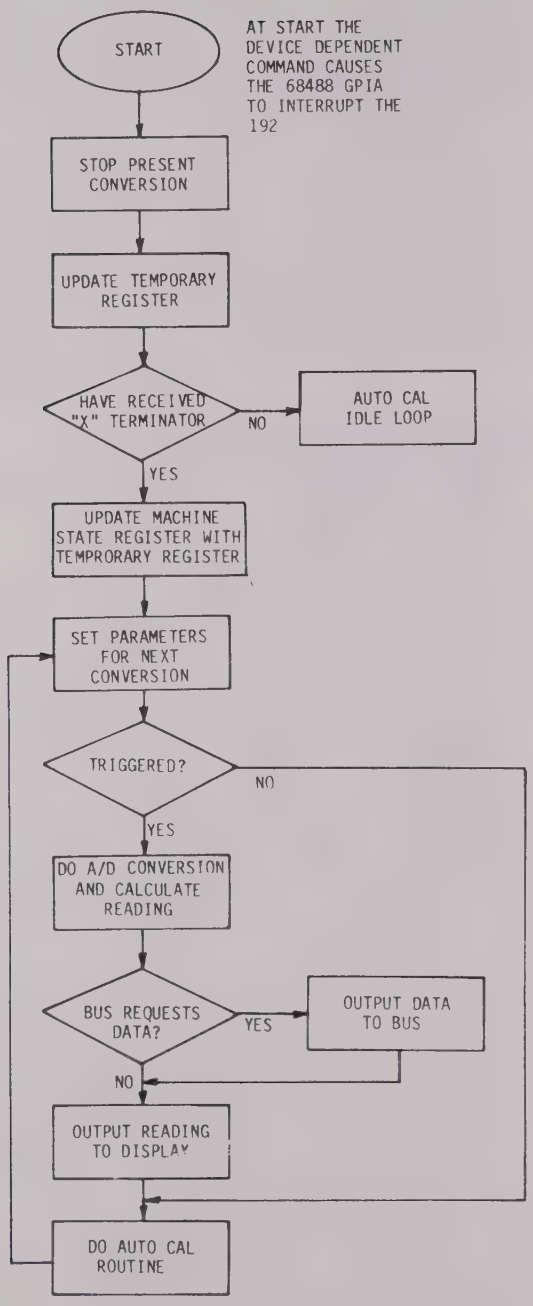


FIGURE 6-13
DEVICE DEPENDENT COMMANDS

6-70. Wait Commands (see Figure 6-14)

6-71. Wait commands program settling time.

W0: Do Not Wait
W1: Wait 10ms before start of signal integrate.

6-72. End of String

6-73. These commands are used to enable or disable the EOI Terminator response.

K0: Send EOI with last byte.
K1: Do not send EOI with last byte.

6-74. Programmable Terminator

6-75. To allow a wide variety of controllers to be used with the Model 192, the 192 can be programmed to send a user defined terminator to the controller. Upon power up, this terminator is set to carriage return line feed and will stay this way until it is reprogrammed. To reprogram the terminator the operator places a Y in the command string, followed by the desired terminator. Any single ASCII character, with the following exceptions, can be used.

EXCEPTIONS

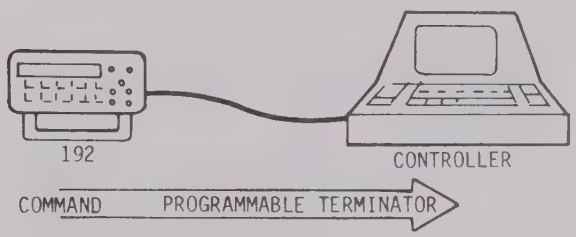
0, 1, 2, 3, 4, 5, 6, 7, 8, 9, F, R, Z, T, S, W, Q, K, M, Y, X, U.

6-76. In addition, three other specific terminators may be used.

A. CRLF - Carriage Return Line Feed
B. LFCR - Line Feed Carriage Return
C. No Terminator

6-77. To program a CRLF terminator, the operator follows the Y with a line feed character. To program a LFCR, enter a carriage return after Y. To delete the terminator the operator places an ASCII "DEL" after Y.

Y(LF) = CRLF
Y(CR) = LFCR
Y(ASCII CHAR) = Any ASCII Character
Y(DEL) = None



6-78. X: Execute (see Figure 6-14)

6-79. Commands sent to the Model 192 are sent a byte at a time. The last command sent is the "X". The X instructs the 192 to accept the previous commands. For example, if the commands F1R2Z0X are sent to the 192, then the following will happen. The controller outputs an F, and the 192 puts F into its temporary register.

F1R2Z0X

The 192 checks the "F" to see if it is an "X". Since "F" is not on "X" command, the 192 branches into an idle state. Next the Controller outputs the "1".

F1R2Z0X

The 192 puts "1" into its temporary register. The 192 checks the "1" to see if it is an "X". Since "1" is not an "X" command, the 192 branches into the idle loop. Next the controller outputs the "R"

F1R2Z0X

The "R" is placed into the temporary register and checked for "X" as the previous characters were. The controller continues sending one character at a time.

F1R2Z0X

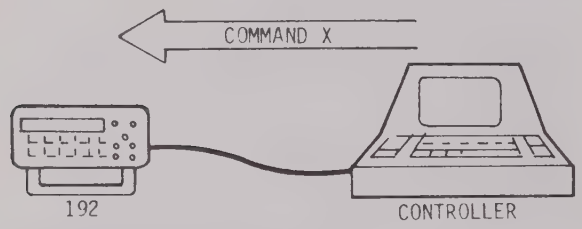
The 192 stores each character and checks it to see if it is "X". When an "X" is received by the 192, the "X" is put into the temporary register.

F1R2Z0X

The 192 checks to see if this is an "X". Since this is an "X", the 192 branches to "update machine state register". The contents of the temporary register are then transferred to the machine state register. The 192 now assures the functions of the respective commands in the machine state register. Function is set to "ACV" (F1). Range is set to "2V" (R2). Zero is turned off (Z0).

NOTE

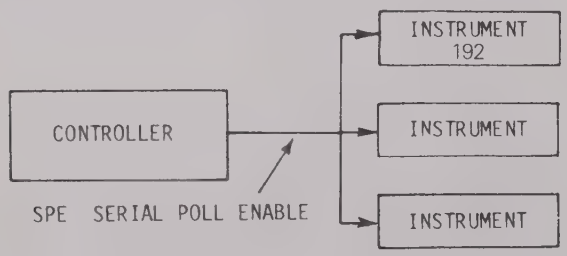
The device dependent commands that were not programmed will remain the same. For example, if the commands F2R4S3X were programmed, then only these commands will be changed (into their respective machine states). Commands such as T0, W1, M0 will not be changed.



6-80. STATUS COMMAND GROUP

6-81. Serial Polling

6-82. Serial Polling is a method to send the status from one or more instruments to a controller. Information is sent to the controller from one instrument at a time. The programmer can select one of two ways to handle serial polling. The controller can be programmed to check the device status using the "SPE" and "SPD" commands, or the controller can be programmed to monitor the "SRQ" signal. Whenever the 192 is in an error condition, or the 192 has data and is programmed not to TALK, then the 192 pulls the "SRQ" low. The "SRQ" line is a single wire in the IEEE Bus. It is connected to all instruments in a wired "OR" condition. Therefore, when the "SRQ" line is pulled low, the controller must poll all instruments to learn which instrument requested service.



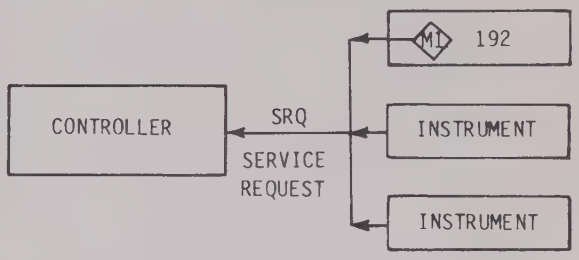
The 192 has programmable bus response modes. These modes are as follows:

M0: Standard Mode - The 192 will not access SRQ.

M1: Interrupt Mode - The 192 will access SRQ.

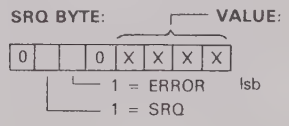
NOTE

The 192 continuously updates its status. Status is current regardless of the bus response mode selected (M0 or M1).



6-83. Serial Poll Data Format (see Figure 6-15)

6-84. Status data from all instruments is not the same. Formatting of status data for the Model 192 is shown below.



The Status Byte, as shown above, can be used to learn operational status of the 192. Use the flow chart below to determine the specific condition of the 192.

6-85. 192 OUTPUT DATA (see Figure 6-16)

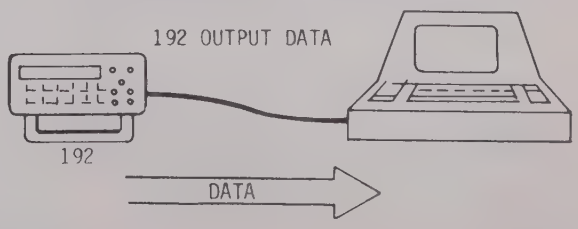
6-86. Output Data consists of 16 bytes plus a terminator.

STATUS	N	= Normal
	Z	= Zeroed
	O	= Overflow
FUNCTION	DCV	= Direct Current Volts
	ACV	= Alternating Current Volts
	OHM	= Ohms
DISPLAY	+	= Positive Reading
	–	= Negative Reading
	1-7	= Reading

NOTE:

The display will remain seven digits regardless of the conversion rate.

EXPONENT	E	= Letter prefix for exponent
	+	= Positive Exponent
	–	= Negative Exponent
	0	= Exponent (0 through 9)
TERMINATOR	CRLF	= Programmable Terminator



Output Data consists of 16 Bytes Plus a Terminator.

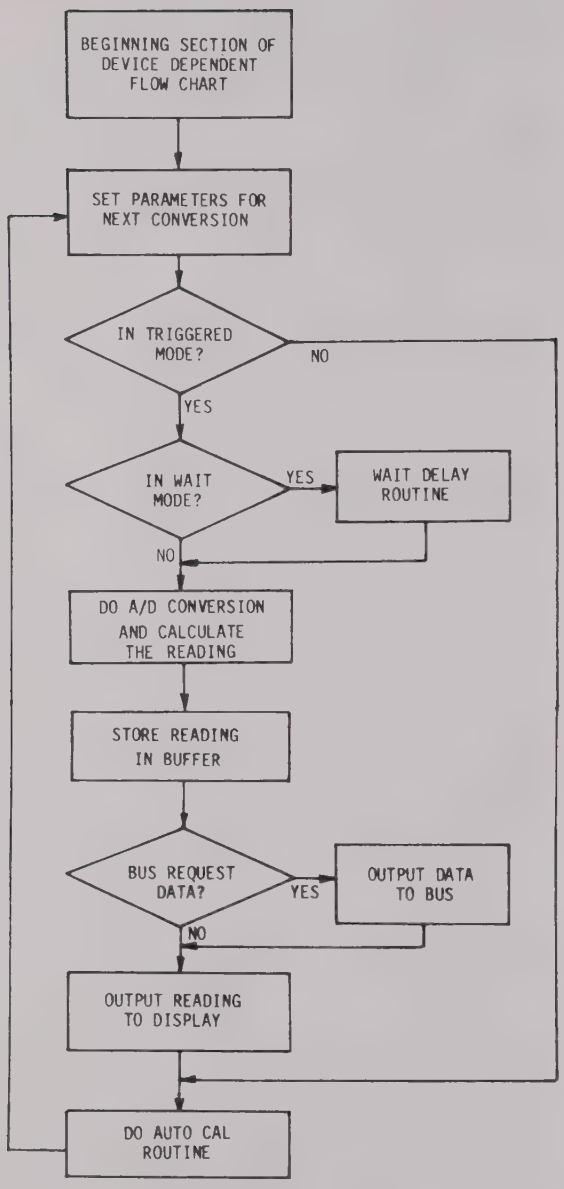


FIGURE 6-14
WAIT COMMAND

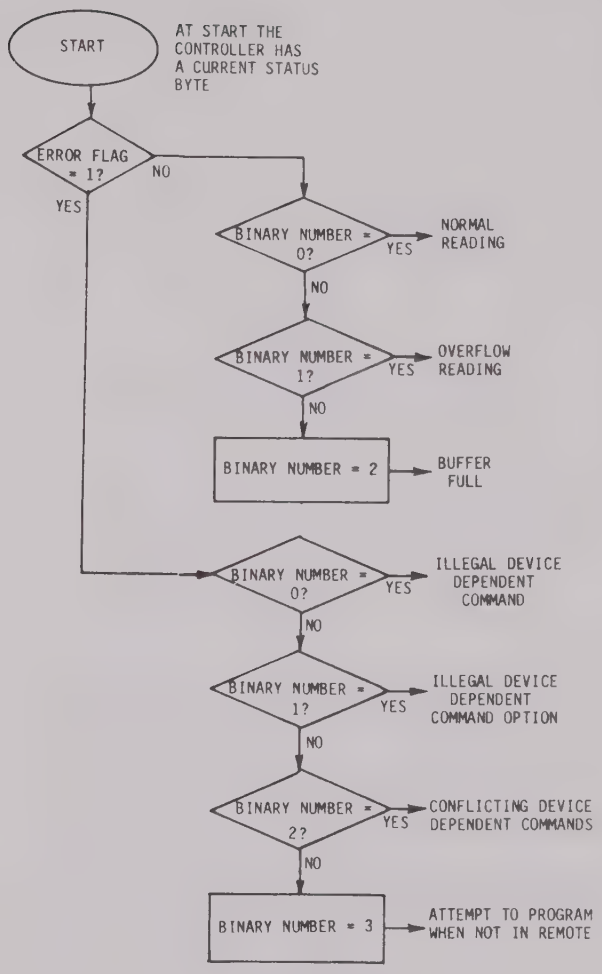


FIGURE 6-15
SERIAL POLL DATA FORMAT

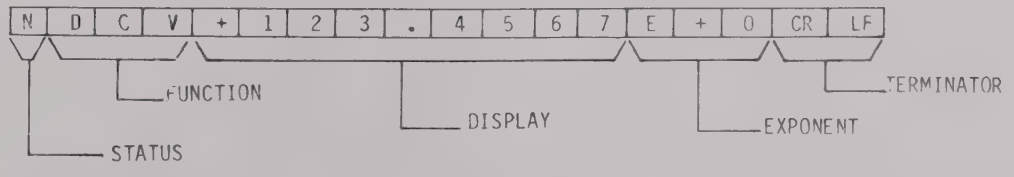


FIGURE 6-16
OUTPUT DATA

SECTION 7. PERFORMANCE VERIFICATION

7-1. GENERAL

The performance verification can be performed upon receipt of the instrument to ensure that no damage or misadjustment has occurred during transit. Verification can also be performed whenever there is question of the instrument's accuracy, and following calibration, if desired.

NOTE

If instruments that are still under warranty (less than 12 months since date of shipment), and the instrument's performance falls outside of specifications at any point, immediately contact your Keithley representative or the factory.

7-2. Environmental Conditions

All measurements should be made at an ambient temperature within the range of 18° to 28°C (65° to 82°F) and a relative humidity of less than 80 percent.

7-3. Recommended Test Equipment

Recommended test equipment for performance verification is listed in Table 7-1. Alternate test equipment may be used. However, if the accuracy of the alternate test equipment is not at least three times better than the instrument specifications, additional allowance must be made in the readings obtained.

Some of the equipment listed in Table 7-1 is not three times better than the 192 specifications because such equipment is not readily available. In these instances, the verification procedures indicate the equipment manufacturer's specified uncertainty, and include the uncertainty in determining the allowable reading for the Model 192.

7-4. Initial Conditions

Before beginning the verification procedures, the instrument must meet the following conditions:

A. If the instrument has been subjected to extremes of temperature, allow sufficient time for internal temperatures to reach environmental conditions as mentioned in Paragraph 7-3. Typically, it takes one hour to stabilize a unit that is 10°C (18°F) out of the specified temperature range.

B. Turn the Model 192 on and allow it to warm up for one hour.

WARNING

Some procedures require the use of high voltage. Take care to prevent contact with live circuits which could cause electrical shock resulting in injury or death.

7-5. DC Voltage Accuracy Check (20V to 2000V ranges)

A. Select the DC volts function. This is done manually by pressing the DCV button on the front panel. If the Model 1923 is installed, it can be programmed over the bus to DCV by programming FØ.

B. Connect the DC calibrator (Item A, Table 7-1) to the 192's DCV terminal.

C. Select the 20V range. This is done manually by pressing the 20V range button on the front panel. Again, if the Model 1923 is installed, the 192 can be programmed over the bus to the 20V range by programming R3.

D. Apply a positive 10VDC to the 192. The reading must be within the limits specified in Table 7-2.

E. Select the 200V range either manually or automatically. Do it manually by pressing the 200V button on the front panel. If the Model 1923 is installed, the 192 can be programmed over the bus to the 200V range by programming R4.

F. Apply a positive 100VDC to the 192. The reading must be within the limits specified in Table 7-2.

TABLE 7-1
RECOMMENDED TEST EQUIPMENT
FOR PERFORMANCE VERIFICATION

ITEM	DESCRIPTION	SPECIFICATION	MFR.	MODEL
A	DC Calibrator	10V, 100V, 1000V ±0.002% or 20μV	Fluke	343A
B	AC Calibrator	0.1V, 1V, 10V, 100V ±0.022%	H-P	745A
C	High Voltage Amplifier (Used with Model 745A)	1000V ±0.04%	H-P	746A
D	Decade Resistor	190Ω, 1.9kΩ, 19kΩ, 190kΩ, 1.9MΩ, 10MΩ ±0.01%	ESI	RS725
E	Kelvin-Varley Voltage Divider (Used with Model 343A)	.19V, 1.9V with .2ppm Terminal Linearity	Fluke	720A

G. Select the 2000V range either manually or automatically. To do this manually press the 2000V button on the front panel. If the Model 1923 is installed, the 192 can be programmed over the bus to the 2000V range by programming R5.

CAUTION

The 2000V range will overrange at over 1200V. As specified clearly on the front panel beneath the DCV button, 1.2kV is the maximum allowable voltage that can be applied without damaging the instrument.

H. Apply a positive 1000VDC to the 192. The reading must be within the specified limits in Table 7-2.

I. Repeat all checks with negative voltage.

TABLE 7-2
DC VOLTAGE PERFORMANCE CHECK
(20V TO 2000V RANGE)

Range	Applied Voltage	Allowable Readings at 18° to 28°C
20V	10.0000V	9.9988 to 10.0012V
200V	100.000V	99.987 to 100.013V
2000V	1000.00V	999.86 to 1000.14V

7-6. DC Voltage Accuracy Check (200mV to 2V ranges)

A. Select the DC Volts function. Refer to Paragraph 7-5A.

B. Select the 200mV range. This is done manually by pressing the 200mV button on the front panel. If the Model 1923 is installed, the 192 can be programmed over the bus into the 200mV range by programming R1.

C. Connect the DC calibrator (Item A Table 7-1, Kelvin-Varley Voltage Divider (Item E) and Model 192 as shown in Figure 7-1.

D. Dial the Kelvin Varley Voltage divider to zero. Then press the 192 ZERO button for a display indication of 00.0000 ±1 digit.

E. Reconnect the DC calibrator (Item A) and set it to an output of +10.00000V.

F. Verify that the Model 192 reading is between .189975 and .190025. Note that the allowable reading includes a ±6 digit allowance for the uncertainty of the DC calibrator (Item A) and Kelvin-Varley Voltage Divider (Item E).

G. Repeat Steps D thru F with negative voltage, and be sure to rezero.

H. Select the 2V range either manually by pressing the 2V button on the front panel or automatically over the bus (If the Model 1923 is installed) by programming R2. Set the Kelvin-Varley Voltage Divider (Item E) to .190000 output.

I. Verify that the Model 192 reading is between 1.89981 and 1.90019. Note that the allowable reading includes ±4 digits for DC calibrator (Item A) uncertainty.

J. Repeat Step I with negative voltage.

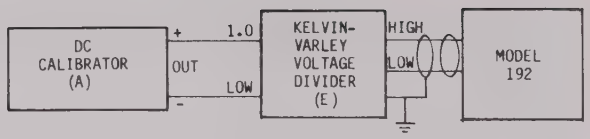


FIGURE 7-1
TEST CIRCUIT 200mV AND 2V

7-7. AC Voltage Accuracy Check (With Model 1910 AC Voltage Option Installed)

A. Select the AC Voltage function. This can be accomplished two ways, either manually by pressing the ACV button or automatically by programming F1 (if the Model 1923 is installed).

B. Connect the AC calibrator (Item B, Table 7-1) to the 192 ACV terminals. Set the AC calibrator to 1kHz.

C. Set the 192 to the 2V range by pressing the 2V button on the front panel or, if the Model 1923 is installed, it can be programmed to the 2V range by programming R2. Apply 1VAC to the 192. Verify that the reading is within the limits specified in Table 7-3.

D. Repeat Steps B and C for the 20V range and then the 200V range. Apply the required voltages specified in Table 7-3. Verify that the readings are within the limits specified in Table 7-3.

E. To check the 1000V range, connect the High Voltage Amplifier (Item C, Table 7-1) to the output of the AC calibrator per the manufacturer's instructions. Select the 1000V range by pressing the 2000 button on the front panel. Connect the amplifier output to the Model 192 INPUT terminals. Set the AC calibrator (Items B and C) for amplifier output of 1000.0V at 1kHz. Verify that the 192 reading is within the specified limits in Table 7-3.

F. To check accuracy at 50Hz, 20KHz and 100kHz, select the 20V range, apply the voltage specified in Table 7-3 at 50Hz, then repeat at 20kHz and 100kHz. Verify that the 192 readings are within the specified limits in Table 7-3.

TABLE 7-3
AC VOLTAGE ACCURACY CHECK

Range	Applied Voltage	Allowable Readings at 18° to 28°C
	at 1kHz	
2V	1.000V	.99868 to 1.00132V
20V	10.000V	9.9868 to 10.0132V
200V	100.00V	99.868 to 100.132V
1000V	1000.0V	998.00 to 1002.00V
	at 50Hz	
20V	10.000V	9.9868 to 10.0132V
	at 20kHz	
20V	10.000V	9.9868 to 10.0132V
	at 100kHz	
20V	10.000V	9.90 to 10.10V

7-8. Resistance (Ω) Accuracy Check

A. Select resistance (Ω) function by depressing the kΩ button on the front panel, or if the Model 1923 is installed, program it into the resistance function by programming F2.

NOTE

The .2kΩ, 2kΩ and 20kΩ ranges performance verification will be done on four-terminal ohms, that is, utilizing the Ω terminal as well as the Ω sense terminal. For the four-terminal measurements, connect the sense leads to the circuit to be measured and the Ω sense terminals to the 192. This arrangement eliminates the error due to the voltage drop across the current-carrying leads. The ZERO button also accomplishes this. It is recommended that both be used to compensate for lead resistance.

B. ZERO Check

1) Connect the Ω's terminals together (short them) with a low thermal shorting plug.

2) Press the ZERO button and verify each Ω's range as specified in Table 7-4.

TABLE 7-4
ZERO READINGS

Range	Allowable Reading
.2 kΩ	.00000 ± 10 digits
2 kΩ	0.0000 ± 2 digits
20 kΩ	00.000 ± 2 digits
200 kΩ	000.00 ± 2 digits
2000 kΩ	0000.0 ± 2 digits
20MΩ	00.000 ± 2 digits

C. Select the .2kΩ range by pressing the .2 button on the front panel or, if the Model 1923 Remote Programming Option is installed, the 192 can be programmed into the .2 range by programming R1.

D. Connect the decade resistor (Item D) to the Ω terminals and the Ω sense terminals.

E. Set the decade resistor to zero and compensate for any residual lead resistance by pressing the ZERO button for a display indication of .000000 ± .000001 flashing.

F. Set the decade resistor to 190Ω. Verify that the reading for the .2kΩ range is within the limits specified in Table 7-5.

G. Select the 2kΩ range by pressing the 2k button on the front panel or program it into the 2kΩ range by programming R2 (if the 1923 option is installed). Set the decade resistor to zero and reset the ZERO button.

H. Set the decade resistor to 1.900kΩ. Verify that the reading is within the limits specified in Table 7-4.

I. Select the 20kΩ range. Set the decade resistor to zero and reset the ZERO button.

J. Set the decade resistor to 19.00kΩ. Verify that the reading is within the limits specified in Table 7-5.

K. Select the 200kΩ range and remove Ω sense leads. Set the decade resistor to zero and reset the ZERO button.

L. Set the decade resistor to 190.00kΩ. Verify that the reading is within the limits specified in Table 7-5.

M. Select the 2000kΩ range. Set the decade resistor to zero and reset the ZERO button.

N. Set the decade resistor to 1900kΩ. Verify that the reading is within the limits specified in Table 7-5.

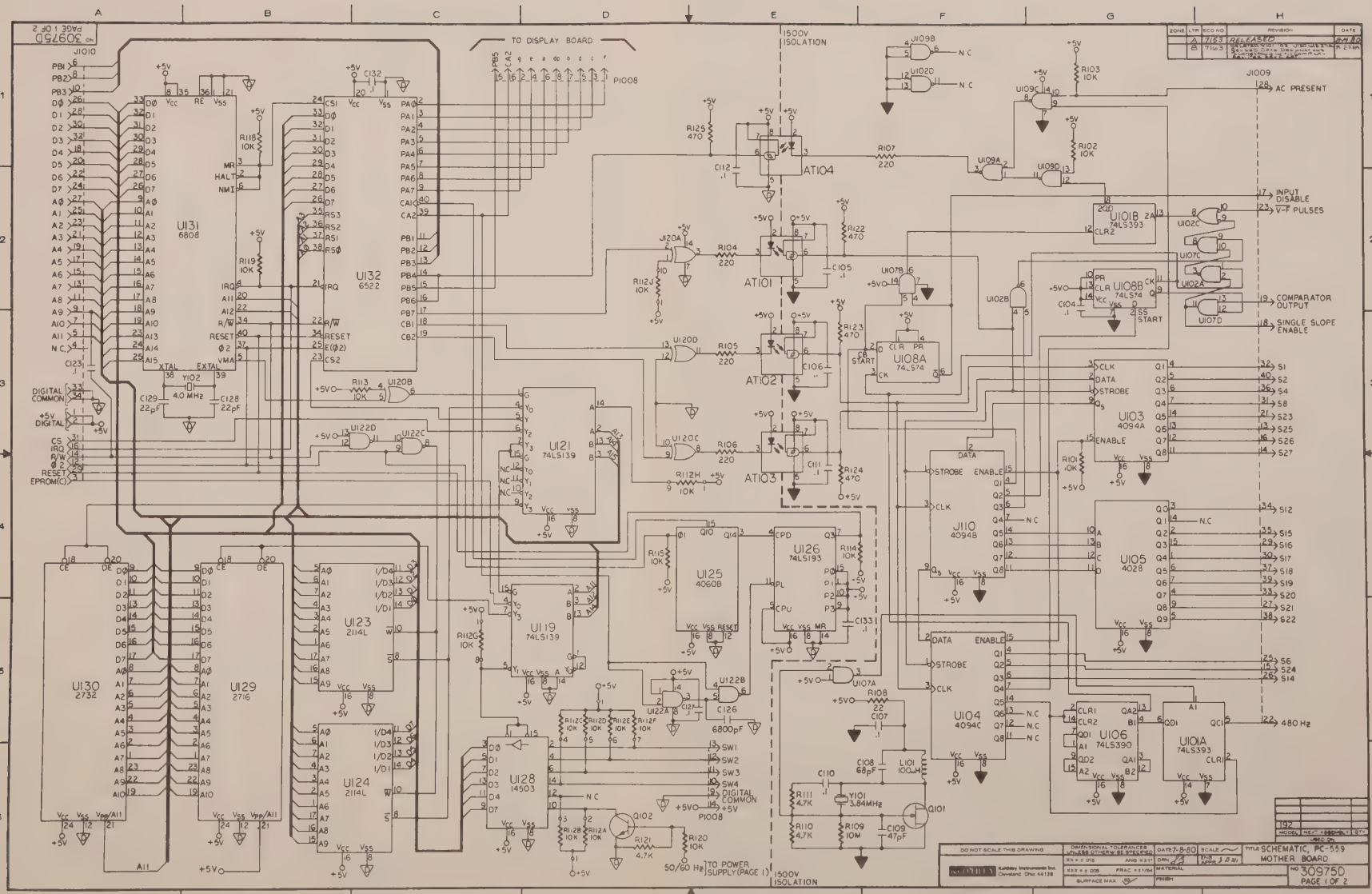
O. Select the 20MΩ range. Set the decade resistor to zero and reset the ZERO button.

P. Set the decade resistor to 10.000MΩ. Verify that the reading is within the limits specified in Table 7-5.

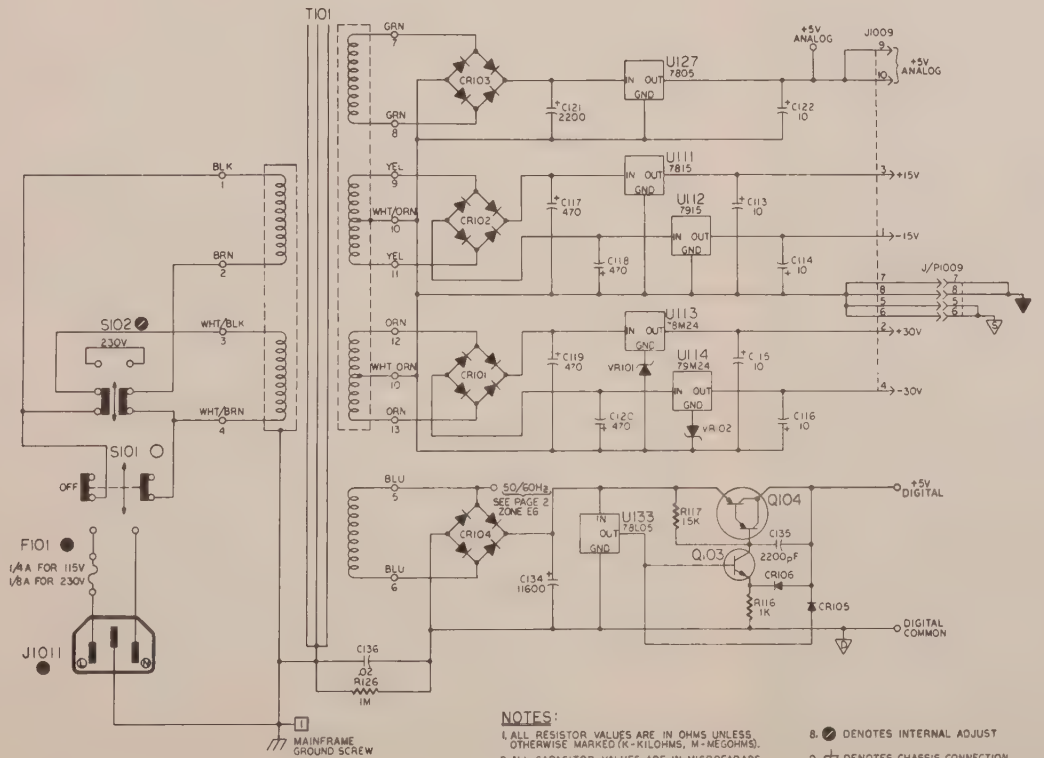
TABLE 7-5
RESISTANCE ACCURACY CHECK

Range	Resistance	Allowable Readings at 18° to 28°C	*
.2 kΩ	.19000 kΩ	.189960 to .190040	± 19 digits
2 kΩ	1.9000 kΩ	1.89960 to 1.90040	± 19 digits
20 kΩ	19.000 kΩ	18.9960 to 19.0040	± 19 digits
200 kΩ	190.00 kΩ	189.960 to 190.040	± 19 digits
2000 kΩ	1900.0 kΩ	1899.60 to 1900.40	± 19 digits
20MΩ	10.0000MΩ	9.9949 to 10.0051	± 10 digits

*Manufacturer's specified uncertainty of the decade resistor (D) in digits. This uncertainty has been added to the specified accuracy of the Model 192 to obtain the allowable reading


TO DISPLAY BOARD
1500V ISOLATION
U131 6808
U132 6522
U121 74LS139
U119 74LS139
U125 4060B
U126 74LS193
U123 2114L
U124 2114L
U130 2732
U129 2716
U128 14503
U110 4094B
U104 4094C
U103 4094A
U105 4028
U106 74LS390
U101A 74LS393
U101B 74LS393
U108A 74LS74
U108B 74LS74
AT101
AT102
AT103
AT104
Y102 4.0 MHz
Y101 3.84MHz
AC PRESENT
INPUT DISABLE
V-F PULSES
COMPARATOR OUTPUT
SINGLE SLOPE ENABLE
START
480 Hz
50/60 Hz
TO POWER SUPPLY (PAGE 1)
DIGITAL COMMON
SCHEMATIC, PC-559
MOTHER BOARD
309750
PAGE 1 OF 2

ZONE	LTR	ECO NO.	REVISION	DATE
	A	7153	RELEASED	6-80
	B	7195	SEE PAGE 1	9-80



NOTES:

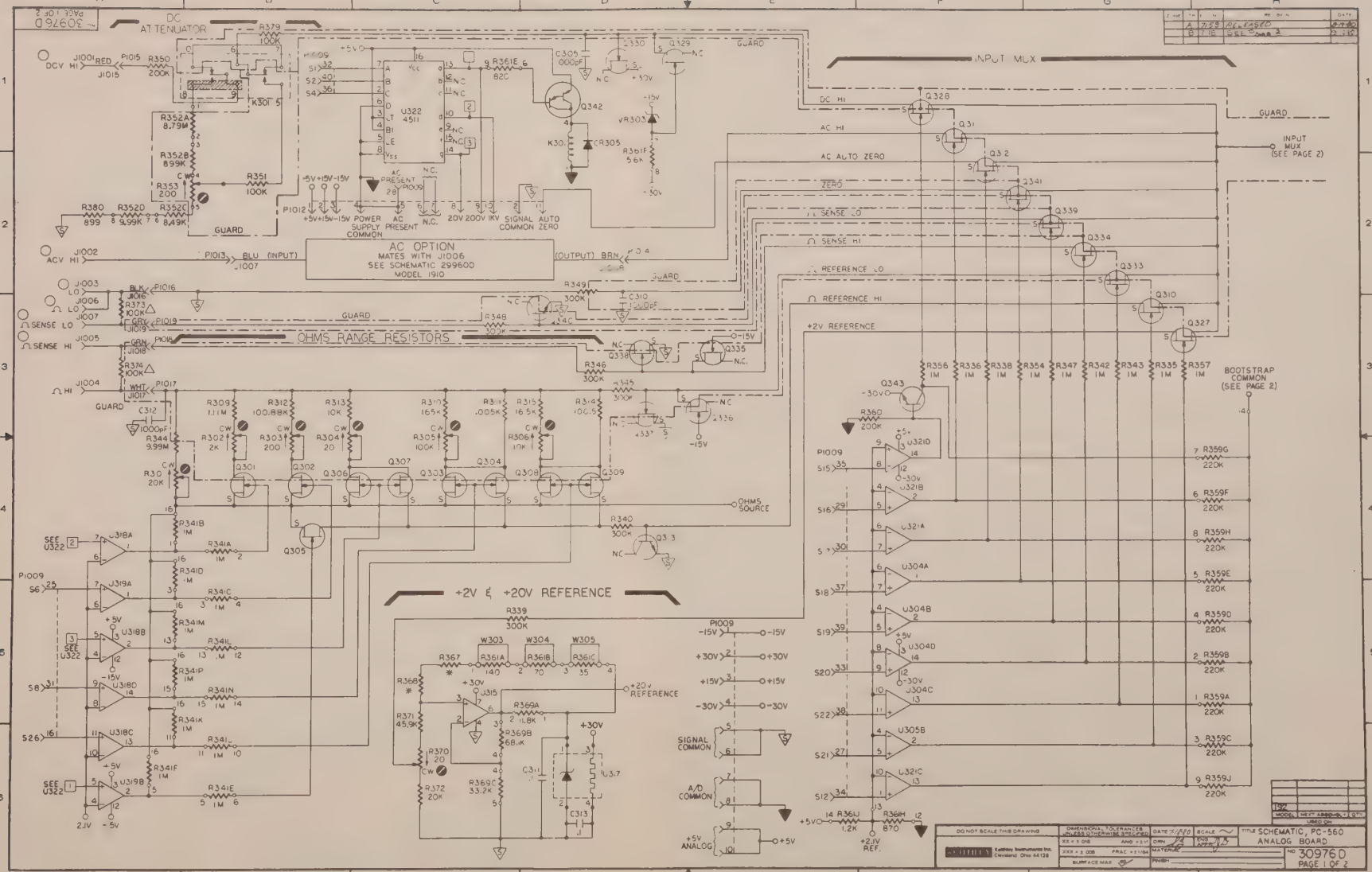
1. ALL RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE MARKED (K-KILOHMS, M-MEGOHMS).
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE MARKED (pF-PICOFARADS).
3. ▽ DENOTES DIGITAL COMMON.
4. ▽ DENOTES SIGNAL COMMON.
5. ▼ DENOTES A/D COMMON.
6. ○ DENOTES FRONT PANEL CONTROL.
7. ● DENOTES REAR PANEL MOUNTING.
8. ⊘ DENOTES INTERNAL ADJUST
9. /// DENOTES CHASSIS CONNECTION.

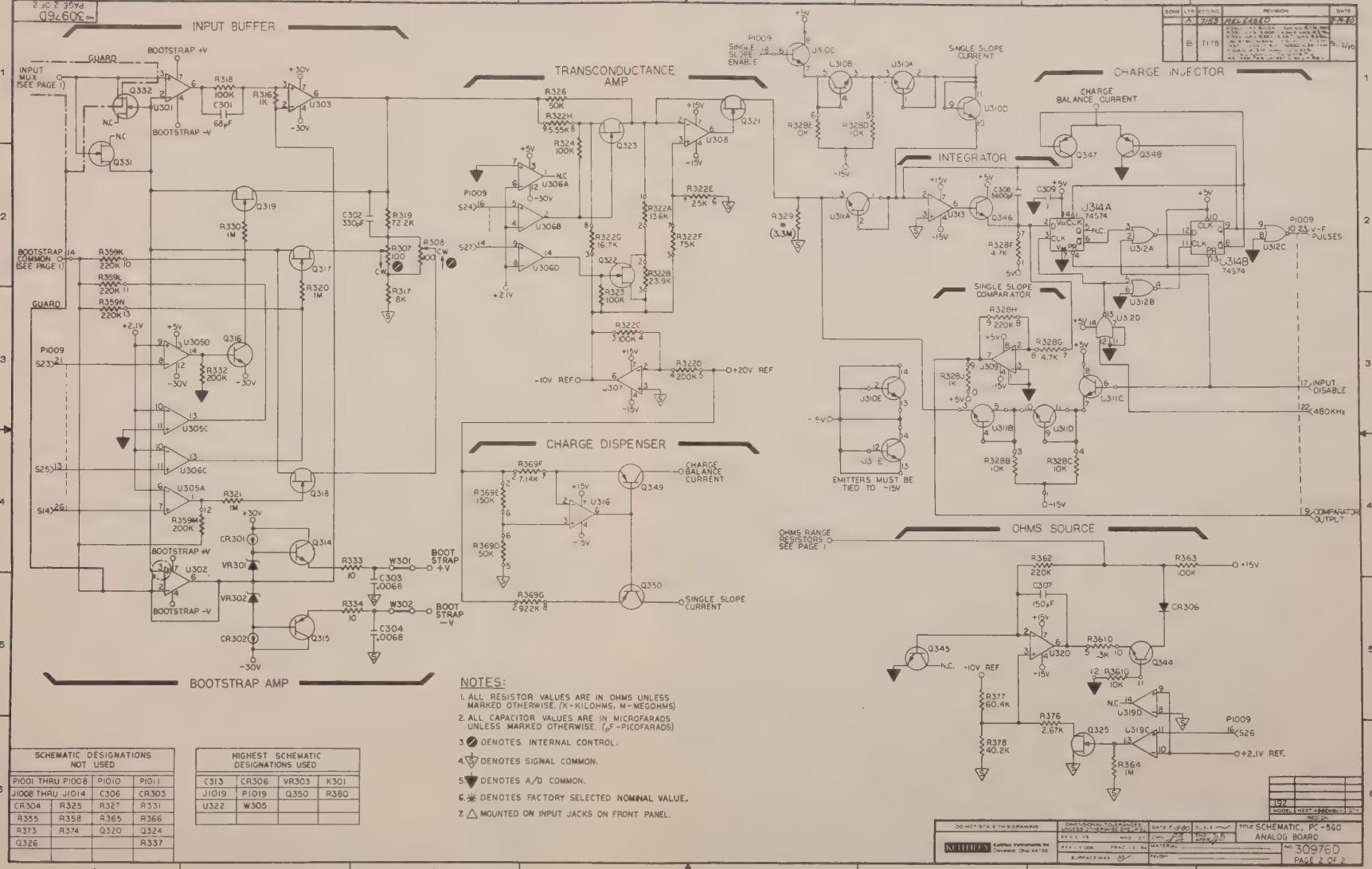
HIGHEST SCHEMATIC DESIGNATIONS USED			
C136	CR106	VR102	S102
R126	U133	J1011	T101
Q104	F101	P1008	AT104
Y102	L10		

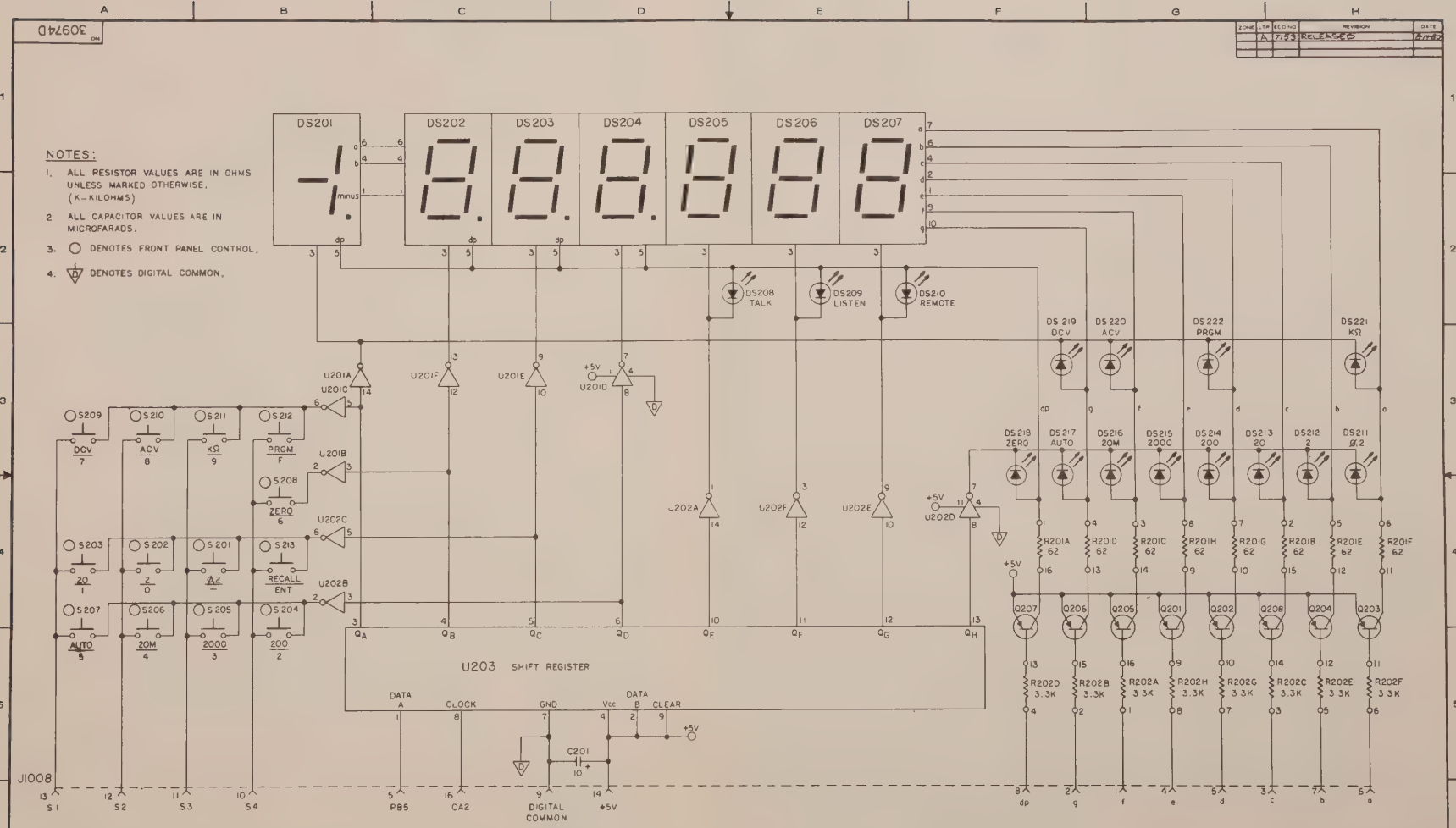
SCHEMATIC DESIGNATIONS NOT USED	
J1001 THRU J1008	
P100 THRU P1007	
U115 THRU U118	

DO NOT SCALE THIS DRAWING	DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE 7-10-80	SCALE ~	TITLE SCHEMATIC, PC-555 POWER SUPPLY
Keithley Instruments Inc. Cleveland, Ohio 44139	XX ± .015 ANG ± 1°	DRN	ENG APPR. J.D.H.	NO 30975D
	XXX ± .005 FRAC ± 1/64	MATERIAL		PAGE 2 OF 2
	SURFACE MAX 63	FINISH		

FORM 285110


DC ATTENUATOR
INPUT MUX
AC OPTION
MATES WITH J1006
SEE SCHEMATIC 299600
MODEL 1910
OHMS RANGE RESISTORS
+2V & +20V REFERENCE
BOOTSTRAP COMMON (SEE PAGE 2)
INPUT MUX (SEE PAGE 2)
OHMS SOURCE
+20V REFERENCE
SIGNAL COMMON
A/D COMMON
+5V ANALOG
GUARD
DC HI
AC HI
AC AUTO ZERO
ZERO
SENSE LO
SENSE HI
REFERENCE LO
REFERENCE HI
+2V REFERENCE
SCHEMATIC, PC-560
ANALOG BOARD
309760
PAGE 1 OF 2


INPUT BUFFER
TRANSCONDUCTANCE AMP
CHARGE INJECTOR
INTEGRATOR
SINGLE SLOPE COMPARATOR
CHARGE DISPENSER
OHMS SOURCE
BOOTSTRAP AMP
INPUT MUX (SEE PAGE 1)
BOOTSTRAP COMMON (SEE PAGE 1)
GUARD
BOOTSTRAP +V
BOOTSTRAP -V
SINGLE SLOPE ENABLE
SINGLE SLOPE CURRENT
CHARGE BALANCE CURRENT
-10V REF
+20V REF
+2.1V REF.
OHMS RANGE RESISTORS SEE PAGE 1
EMITTERS MUST BE TIED TO -15V
INPUT DISABLE
480KHz
COMPARATOR OUTPUT
V-F PULSES
BOOT STRAP +V
BOOT STRAP -V
SINGLE SLOPE CURRENT
NOTES:
1. ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE. (K=KILOHMS, M=MEGOHMS)
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS MARKED OTHERWISE. (pF=PICOFARADS)
3. ⊘ DENOTES INTERNAL CONTROL.
4. ▽ DENOTES SIGNAL COMMON.
5. ▼ DENOTES A/D COMMON.
6. ✳ DENOTES FACTORY SELECTED NOMINAL VALUE.
7. △ MOUNTED ON INPUT JACKS ON FRONT PANEL.
SCHEMATIC DESIGNATIONS NOT USED
P1001 THRU P1008 P1010 P1011
J1008 THRU J1014 C306 CR303
CR304 R325 R327 R331
R355 R358 R365 R366
R373 R374 Q320 Q324
Q326 R337
HIGHEST SCHEMATIC DESIGNATIONS USED
C313 CR306 VR303 K301
J1019 P1019 Q350 R380
U322 W305
DO NOT SCALE THIS DRAWING
TITLE SCHEMATIC, PC-560 ANALOG BOARD
NO 30976D
PAGE 2 OF 2

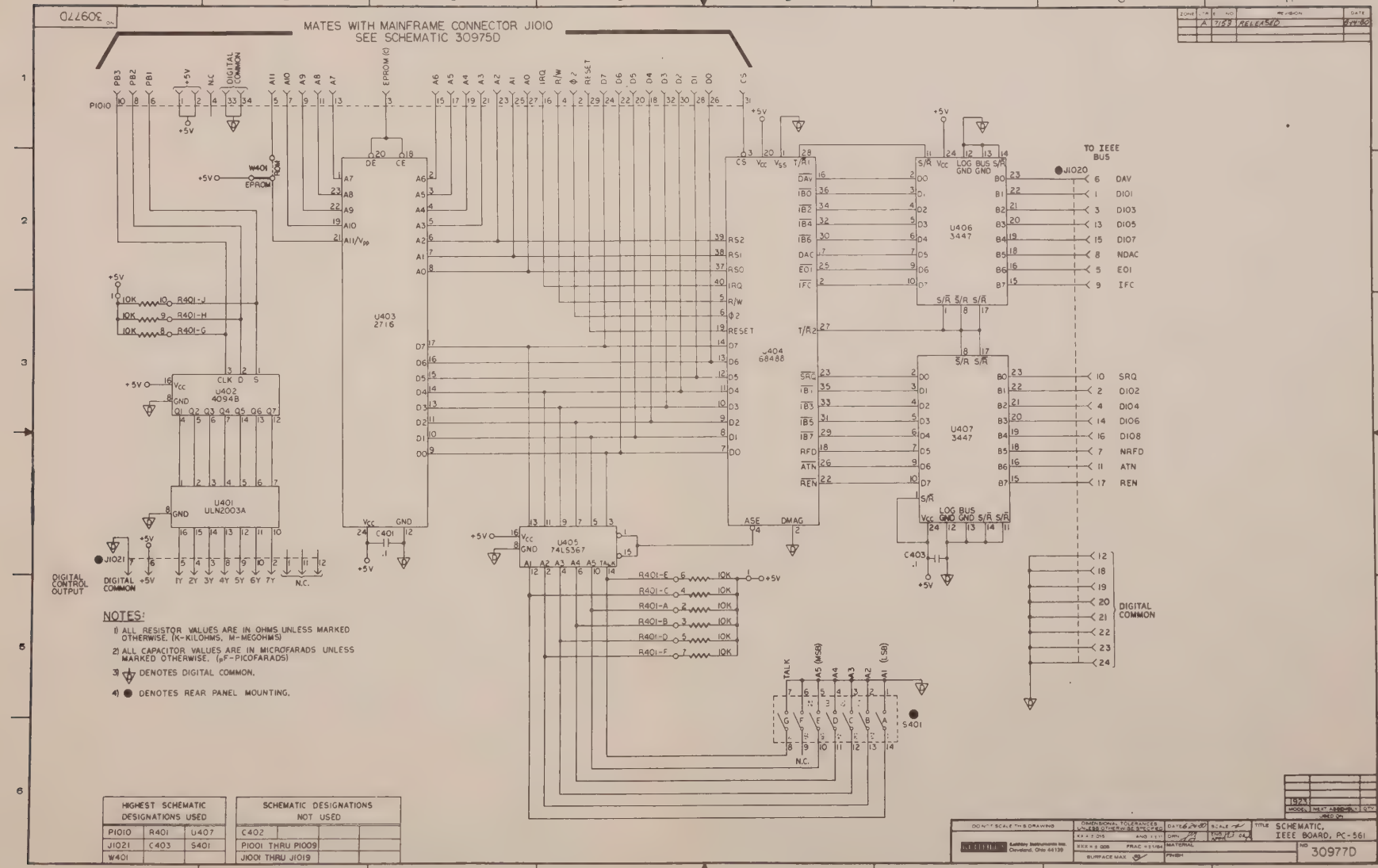


HIGHEST SCHEMATIC DESIGNATIONS USED		
C201	DS222	Q208
R202	S213	U203

SCHEMATIC DESIGNATIONS NOT USED
J1001 THRU J1007

ZONE	LTR	ECO NO	REVISION	DATE
	A	7153	RELEASED	8-7-80

DO NOT SCALE THIS DRAWING
DRN. J. Estley
DATE 4-9-80
SCALE
TITLE SCHEMATIC PC-530 DISPLAY BOARD
NO 30974D
Keithley Instruments Inc Cleveland, Ohio 44139



NOTES:

1) ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE. (K-KILOHMS, M-MEGOHMS)
2) ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS MARKED OTHERWISE. (μF-PICOFARADS)
3) ⏚ DENOTES DIGITAL COMMON.
4) ● DENOTES REAR PANEL MOUNTING.

HIGHEST SCHEMATIC DESIGNATIONS USED		
P1010	R401	U407
J1021	C403	S401
W401		

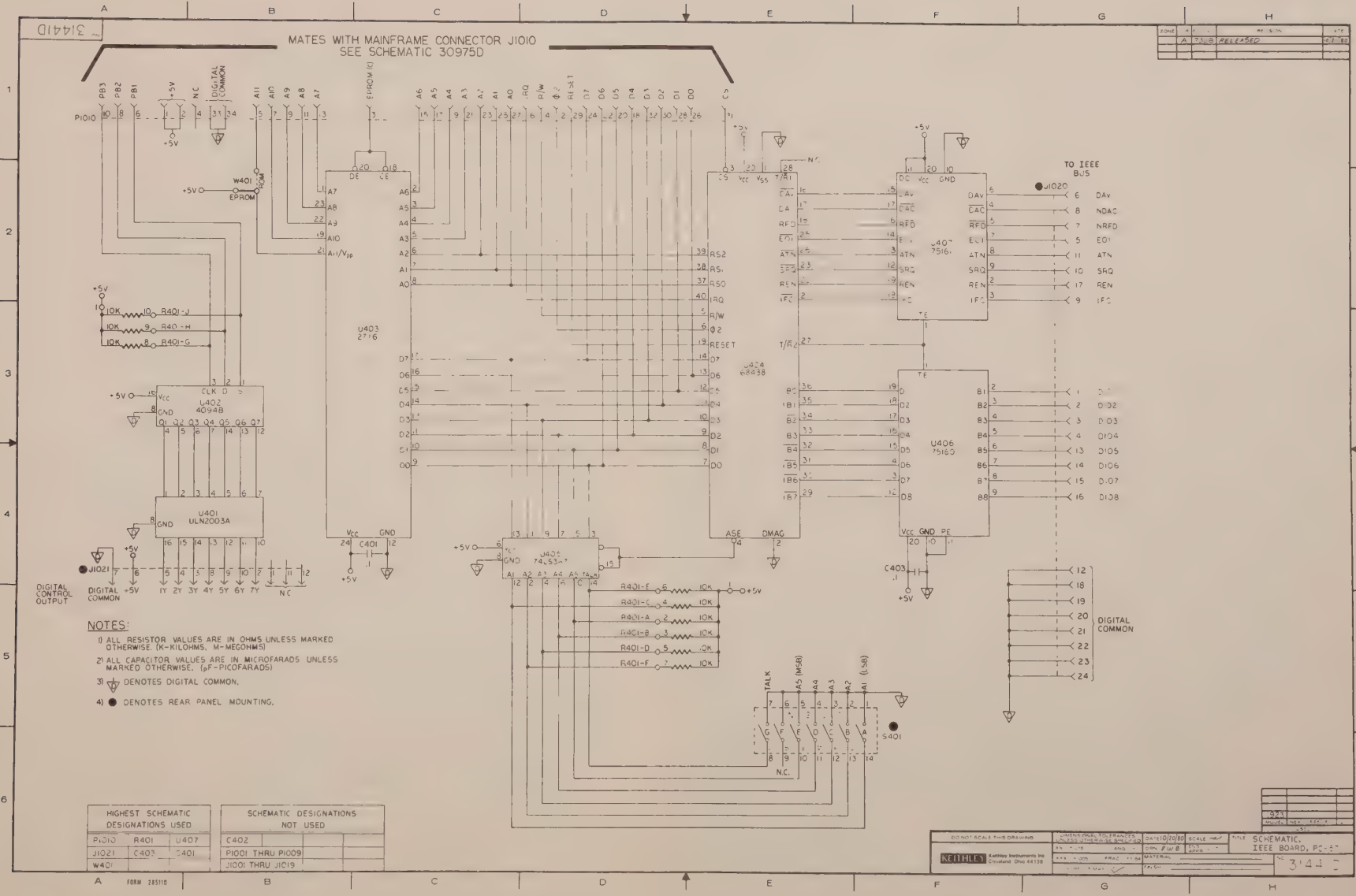
SCHEMATIC DESIGNATIONS NOT USED		
C402		
P1001 THRU P1009		
J1001 THRU J1019		

ZONE	LTR	NO	REVISION	DATE
	A	7169	RELEASED	4-14-80

1923

DO NOT SCALE THIS DRAWING	DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE 6-2-80	SCALE	TITLE SCHEMATIC, IEEE BOARD, PC-561
Tektronix Inc. Beaverton, Oregon	XX ± .05 ANG ± 1°	DRN	TOL	
	XXX ± .005 FRAC ± 1/64	MATERIAL		NO 30977D
	SURFACE MAX	FINISH		

FORM 26511B



NOTES:

1) ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE. (K-KILOHMS, M-MEGOHMS)
2) ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS MARKED OTHERWISE. (pF-PICOFARADS)
3) ⏚ DENOTES DIGITAL COMMON.
4) ● DENOTES REAR PANEL MOUNTING.

HIGHEST SCHEMATIC DESIGNATIONS USED		
P1010	R401	U407
J1021	C403	S401
W401		

SCHEMATIC DESIGNATIONS NOT USED		
C402		
P1001 THRU P1009		
J1001 THRU J1019		

ZONE	LTR	RELEASED	DATE
	A	RELEASED	10-8-80

DO NOT SCALE THIS DRAWING — UNLESS OTHERWISE SPECIFIED: DECIMALS ± .010, ANG ±, FRAC ± 1/64 — DATE 10/20/80 — SCALE — DRN PWB — CHK — MATERIAL — FINISH

KEITHLEY Keithley Instruments Inc. Cleveland Ohio 44139

TITLE: SCHEMATIC, IEEE BOARD, PC-[illegible]

31412

FORM 285110

KEITHLEY INSTRUMENTS, INC.
28775 AURORA ROAD
CLEVELAND, OHIO 44139

SERVICE FORM

MODEL NO._____ SERIAL NO._____ P.O. NO._____ DATE_____ R-

NAME _____ PHONE _____

COMPANY _____

ADDRESS _____ CITY _____ STATE _____ ZIP_____

1. Describe problem and symptoms using quantitative data whenever possible (enclose readings, chart recordings, etc.) _____

_____

_____ (Attach additional sheets as necessary).

2. Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also describe signal source.

3. List the positions of all controls and switches on both front and rear panels of the instrument. _____

_____

4. Describe input signal source levels, frequencies, etc. _____

_____

_____

5. List and describe all cables used in the experiment (length, shielding, etc.).

_____

_____

6. List and describe all other equipment used in the experiment. Give control settings for each. _____

_____

_____

7. Environment:
   Where is the measurement being performed? (Factory, controlled laboratory, out-of-doors, etc.) _____
   What power line voltage is used? _____ Variation? _____ Frequency? _____
   Ambient temperature? _____°F. Variation? _____°F. Rel. Humidity? _____
   Other _____

8. Additional Information. (If special modifications have been made by the user, please describe below.) _____

_____

_____ REV 0774

MP MASTER
MA28525

KEITHLEY

Keithley Instruments, Inc./28775 Aurora Road/Cleveland, Ohio 44139/(216) 248-0400/Telex: 98-5469
Keithley Instruments GmbH/Heiglhofstrasse 5/D-8000 Munchen 70/(089) 714-40-65/Telex: 521 21 60
Keithley Instruments, Ltd./1, Boulton Road/GB-Reading, Berkshire RG2 ONL/(0734) 86 12 87
Keithley Instruments SARL/44, Rue Anatole France/F-91121 Palaiseau Cedex/01-014-22-06/Telex: (842) 204188